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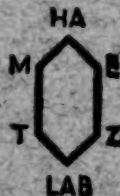
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## SQUAMOUS-CELL EPITHELIOMA OF THE SKIN\*

A STUDY OF 256 CASES

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THE broad term "skin cancer" usually includes basal-cell epithelioma, or rodent ulcer, and squamous-cell epithelioma. As a matter of fact, the term skin cancer should include four types of epithelioma; that is, basal-cell, squamous-cell, melanotic and non-melanotic melano-epithelioma,<sup>4</sup> varying in degree of malignancy with their capacity to cause death in the proportion approximately of 35 for the first, 65 for the second, and 95 for the last two types on the basis of 1 to 100.<sup>3</sup> The recognition of the type of skin cancer being dealt with is of prime importance from the standpoint of prognosis. Carcinomas which originate in the sweat and sebaceous glands should not come under this term any more than carcinoma of the breast, as they originate from the germinal cells of specialized glands of dermal origin.

*Polymorphism of Epithelial Cells.*—No cells of the body are more prone to change their form than are epithelial cells. Not infrequently cells are seen in neoplasms, under the high power of the microscope, which bear a close resemblance to muscle-cells and fibroblasts, but since they can be traced directly to the basal layer of the skin, there can be no doubt with regard to their origin (Figs. 1, 2, 3 and 4).

Kettle, in his article "Polymorphism of the Malignant Epithelial Cell," states:

"That the malignant epithelial cell is capable of polymorphism is perfectly well recognized. The interchangeability of the acinus and the solid structure in adenocarcinoma is familiar to everyone, and the origin of a squamous-cell carcinoma from columnar epithelium has been reported on several occasions. Greater variations than these, however, are not, as a rule, considered possible. It is true Krompecher held that under certain conditions of growth and environment epithelial cells may assume a spindle form and may actually be converted into connective-tissue elements, but his views have not found general acceptance, and the doctrine of the specific nature of cell-growth is not seriously

\* Thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Pathology, May, 1920.

questioned. Without going so far as to claim that the adult epithelial cell can actually become changed into a connective-tissue cell, I am convinced that some carcinomata may possess such extreme powers of polymorphic growth that their cells, losing all trace of their epithelial origin, may become indistinguishable from connective-tissue elements."

Krompecher's view seems somewhat illusory, but considering that the entire body is developed from the fertilized ovum, his theory is brought within the range of possibility. Squamous epithelium does not originate from columnar epithelium, as the columnar cell is differentiated and cannot regenerate. When a squamous-cell epithelioma develops in an organ in which columnar epithelium is found normally, the gall-bladder, for example, the regenerative cells which, under ordinary circumstances produce columnar epithelium, produce squamous epithelium instead. The same process takes place in an everted uterus when protective instead of columnar epithelium is needed.

*Regeneration and Degeneration.*—I believe that the habitual use of the term "cancerous degeneration" is incorrect. MacCarty believes that cancer is a regenerative process and not a degenerative process. Cancer tissue like other tissues degenerates. The enzyme activity of the cancer cells may cause their death and that of other cells. Cancer cells may also be destroyed by being deprived of nourishment by fibrous connective tissue. Whatever affects the general metabolism of the body affects the cancer. As is well known, the cells of our bodies are subject to the two great processes of nature, anabolic and katabolic. the former builds up and the latter tears down. Nourishing diet, fresh air, sunshine, and rest help to cure tuberculosis, but not cancer, which is a part of the body, and when food is prepared and distributed to the normal cells it is also distributed to the cancer cells.

The chronic destruction of epithelial tissue often is followed by cancer, for example, on ulcer of the lip. The destruction of the epithelial cells is a katabolic process and the regeneration by the cells of the germinal layer is an anabolic process. If the anabolic process predominates, the ulcer is healed over by normal epithelium; if the katabolic process predominates, the ulcer continues to grow. If cancer develops on the border of the ulcer, however, the cancer has both regenerative and destructive properties. Cancer cells are undifferentiated cells which have taken over new properties besides their regenerative abilities; that is, the power to invade and migrate, thereby infringing on the rights of other cells, and, depending on their degree of cellular activity, producing death of the entire organism. I believe that pernicious anæmia, myelogenous leukæmia, lymphatic leukæmia, and, in fact, all malignant neoplasias are regenerative-destructive processes, probably following, in the large majority of instances, excessive chronic destruction of differentiated cells, such as pernicious anæmia following the chronic excessive destruction of red blood-cells, and lymphatic leukæmia and lymphosarcoma following

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the chronic excessive destruction of lymphocytes. Maud Slye, in her paper on the relation of pregnancy and reproduction to tumor growth in mice, concludes:

1. "Cancer and reproduction both being growth processes draw upon the same energy residuum and are made possible by the same food. Hence the food and energy used by one are withheld from the other.

2. "Therefore (a) if the female is constantly pregnant, energy and food are withheld from the tumor, and it grows with extreme slowness. (b) If there is a hiatus between pregnancies, or a termination of pregnancy, the energy which was running into reproduction is released and diverted into tumor which grows very rapidly. (c) If tumor growth considerably antedates impregnation, the currents of energy are already being used for tumor growth and are with difficulty diverted for pregnancy, probably never wholly so.

3. "Hence, when a female is well advanced in tumor growth before impregnation there are rarely any offspring brought to birth. When offspring are delivered they are few, small, undernourished and rarely suckled (which in mice means there is no lactation).

4. "When tumor growth is not interfered with by pregnancy, it is (a) extremely rapid in mice which are young, well nourished and vigorous; (b) less rapid in mice older or less vigorous or less nourished; (c) very slow in mice which are old, feeble, undernourished, or afflicted with a destructive complicating disease."

Miss Slye's conclusions are ample proof that cancer is a regenerative-destructive process.

*Cell Differentiation and Activity.*—In a recent paper on squamous-cell epithelioma of the lip,<sup>2</sup> I brought out the fact that the more an epithelioma tends to differentiate, the lower is the degree of malignancy. I believe this principle can be applied to malignant neoplasia in general. Very few melanotic or non-melanotic melano-epitheliomas show any tendency to differentiate, hence the high degree of malignancy; however, gland formations and squamous cells are sometimes found in these neoplasms.

The question has often been asked why the basal-cell epithelioma is of such a low degree of malignancy when it is made up of undifferentiated cells. It has been suggested that basal-cell epithelioma passes through a short cycle and differentiates into basal cells, while squamous-cell epitheliomas pass through a longer cycle in order to differentiate into squamous cells.<sup>5</sup>

It is well known that most of the cells of a basal-cell epithelioma bear a close resemblance to the normal basal or regenerative cells of the epidermis; however, sometimes there are cells in this type of neoplasm which contain round nuclei with deeply staining single nucleoli, "one-eyed cells"; sometimes the nuclei are irregular in outline and contain more than one nucleolus or none. I can see no differentiation in these cells; they bear a striking resemblance to the Grade 4 squamous-cell epithelioma or the melanotic epithelioma. Whenever these cells predominate in a basal-cell epithelioma it is best to give a guarded prognosis because they are liable very rapidly to infiltrate the surrounding tissues. There seems to be no reason why a basal-cell epithelioma with such active cells should not metastasize, and maybe they do.<sup>1</sup>

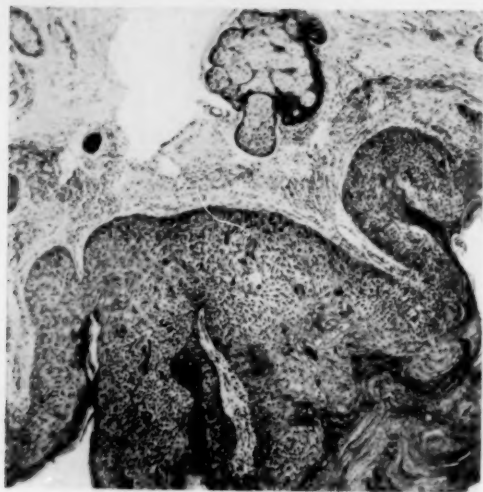


FIG. 1.—Squamous-cell epithelioma of the skin, showing polymorphism of the cells (low power).

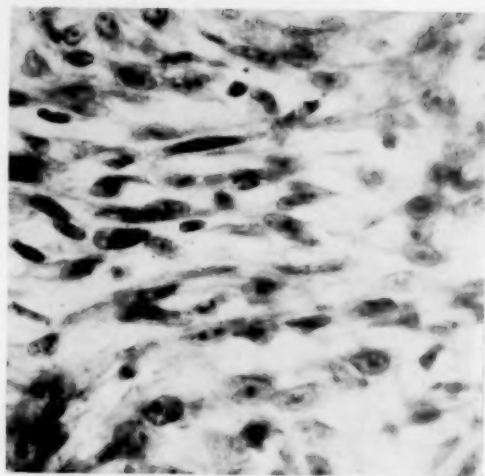


FIG. 2.—High-power magnification of section shown in Fig. 1. Note the close resemblance to fibrosarcoma.



FIG. 3 (Case A33716).—Squamous-cell epithelioma of the skin showing a marked polymorphism of the cells (low power).

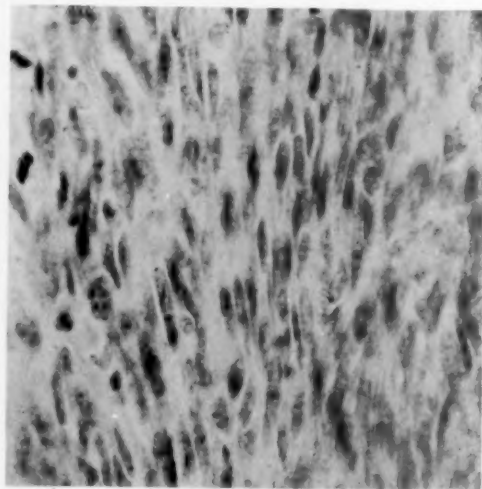


FIG. 4 (Case A33716).—High-power magnification of section shown in Fig. 3. Exact picture of myosarcoma.

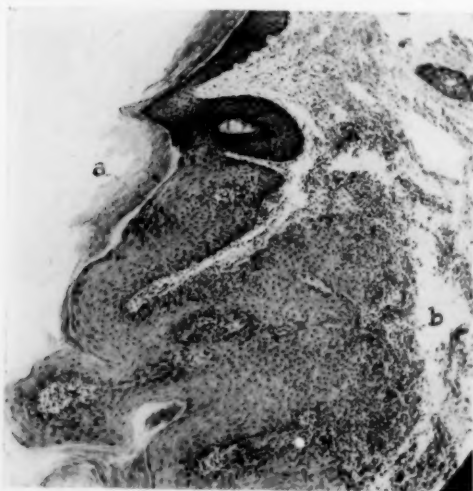


FIG. 5 (Case A19884).—Grade I, epithelioma; a, normal epithelium; b, epithelioma showing marked differentiation.



FIG. 6 (Case A60960).—Grade I, epithelioma; a, normal epithelium; b, epithelioma showing marked differentiation.

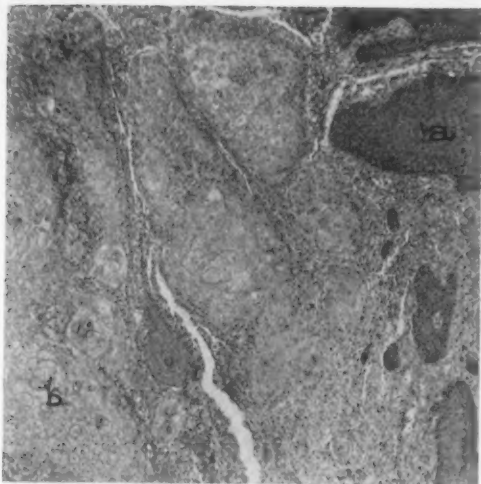


FIG. 7 (Case A95147).—Grade 1 epithelioma; *a*, normal epithelium; *b*, epithelioma showing marked differentiation.

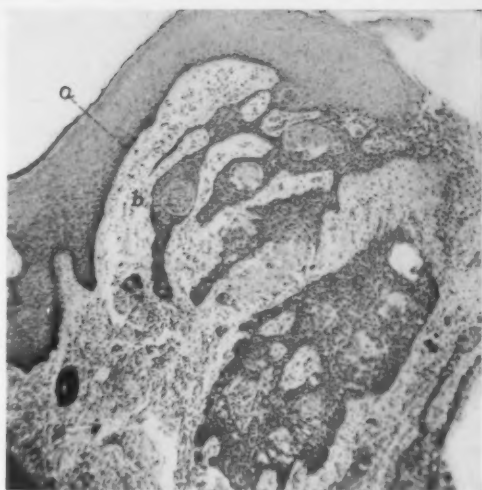


FIG. 8 (Case A75272).—Grade 2 epithelioma; *a*, normal epithelium; *b*, pearly body; *c*, undifferentiated epithelial cells.

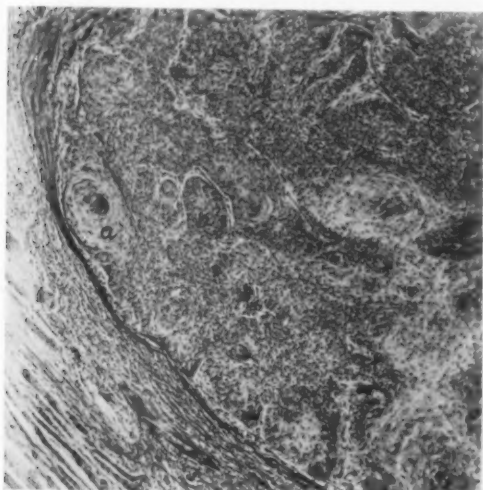


FIG. 9 (Case A90006).—Grade 2 epithelioma; *a*, pearly body; *b*, undifferentiated cells.

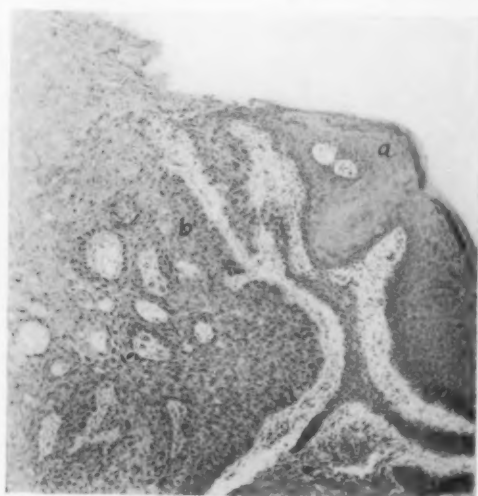


FIG. 10 (Case A34711).—Grade 2 epithelioma; *a*, normal epithelium; *b*, epithelioma.

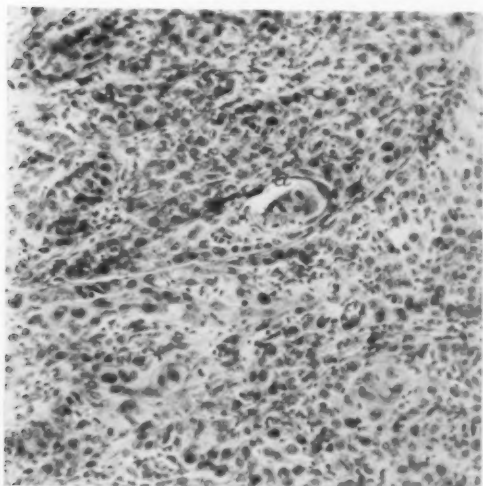


FIG. 11 (Case A53661).—Grade 3 epithelioma; *a*, epithelial cells showing practically complete differentiation.

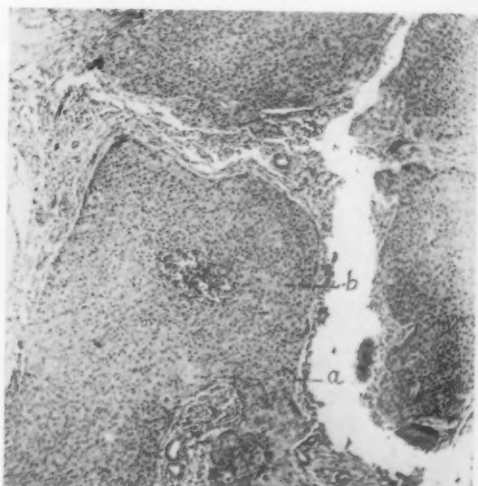


FIG. 12 (Case A220).—Grade 3 epithelioma; *a*, practically completely differentiated cells; *b*, undifferentiated cells.

Frequently areas of pearly bodies are found in a basal-cell epithelioma; these are due to the change from basal cells to squamous cells and from squamous cells to pearly bodies.

The same general plan will be followed in discussing squamous-cell epithelioma of the skin as that in squamous-cell epithelioma of the lip.<sup>2</sup> The degree of cellular activity is graded 1 to 4 on the same basis, namely, if the epithelioma shows a marked tendency to differentiate, that is, if about three-fourths of its structure is differentiated epithelium and one-fourth undifferentiated, it is graded 1 (Figs. 5, 6 and 7); if the percentage of differentiated and undifferentiated epithelium are about equal, it is graded 2 (Figs. 8, 9 and 10); if the undifferentiated epithelium forms about three-fourths and the differentiated about one-fourth of the growth, it is graded 3 (Figs. 11, 12 and 13); if there is no tendency for the cells to differentiate it is graded 4 (Figs. 14, 15 and 16). The number of mitotic figures and the number of cells with single large deeply-staining nucleoli, one-eyed cells, play an important part in the grading. With some experience in the grading of epitheliomas, a picture for each grade becomes fixed in mind, thereby making the grading rather easy. Not all cells with single deeply-staining nucleoli are malignant; however, when they are found in a neoplasm in large numbers it is best to treat the tumor as malignant or promalignant. These cells are regenerative, and, since malignant neoplasia is a regenerative-destructive process, their presence in malignant neoplasms is not out of order.

An endothelial leucocyte is also a one-eyed cell, but it differs from the true one-eyed cell of malignant neoplasia in that it lacks body. Not all malignant cells have a single nucleolus; some have more than one and others have none. As a rule, the more malignant the neoplasm, the more irregular and ill-defined are its cell nuclei; however, exceptions to this are not infrequently seen. A pearly body in a lymph-node is not itself cancer; neither are the large flat squamous cells with small nuclei which lie adjacent to it. The pearly body is a finished product which corresponds to the horny layer of the epidermis. The large flat squamous cell with a small nucleus is almost a finished product; the keratinization of this cell forms the basis of the pearly body (Figs. 17 and 18). The large flat squamous cell with the small nucleus and the pearly body are not cancer when found in a lymph-node, as they are incapable of regeneration. Cells which are incapable of regeneration are not cancer cells. On this reasoning, the basis of grading epitheliomas is formulated.

#### CONCLUSIONS

1. The term "skin cancer" is indefinite and should be discarded.
2. The use of the term "cancerous degeneration" also should be discontinued.
3. The capacity of a cancer to cause death should be known when a prognosis is given.

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4. Cancer is a regenerative-destructive process, resulting in the majority of instances from the interaction of anabolic and katabolic processes.
5. In most cases malignant neoplasia probably follows the chronic excessive destruction of differentiated cells.
6. As a rule, the more marked the differentiation in a squamous-cell epithelioma, the lower is the degree of malignancy.
7. Pearly bodies and large flat squamous cells with small nuclei are not cancer. Cancer is regenerative or undifferentiated cells.
8. The 256 cases in this series of squamous-cell epithelioma of the skin represent 12.8 per cent. of 2000 cases of general epithelioma observed in the Mayo Clinic from November 1, 1904, to July 22, 1915.
9. Squamous-cell epithelioma of the skin occurred more often in males than in females; the proportion is 4 to 1. It occurred in patients past middle life; their average age was fifty-nine and thirty-four hundredths years.
10. Squamous-cell epithelioma occurred most often in farmers; they represented 53.96 per cent. of the cases in males.
11. The site of the cancer was preceded by a mole, wart, pimple, scab, ulcer, leucoplakia, crack, wen, blister, or lump in 51.17 per cent. of the cases.
12. There was a history of injury in 23.82 per cent. of the cases; burns represented 24.59 per cent. of the injuries, and X-ray burns represented 20 per cent. of the burns.
13. The average duration of the lesion was 4.8 years and the average greatest diameter 3.85 cm.
14. Seventy-eight and four hundredths per cent. of all the lesions occurred above the clavicle.
15. Twenty-eight and twelve hundredths per cent. of the patients were treated with acid, paste or plaster, and so forth, before they entered the clinic.
16. Twenty-six and ninety-five hundredths per cent. of the patients were operated on before they entered the clinic.
17. Ninety-two and eighteen hundredths per cent. of the patients were operated on at the clinic.
18. Regional lymph-nodes or salivary glands were not removed in 77.96 per cent.
19. Of the 22.03 per cent. of the cases in which the regional lymph-nodes or salivary glands were removed, metastasis was demonstrated in 61.53 per cent.
20. The cervical lymph-nodes were involved in 31.25 per cent., sub-maxillary lymph-nodes in 28.12 per cent., the parotid lymph-nodes in 25 per cent., the parotid salivary gland in 25 per cent., and the axillary and inguinal lymph-nodes each in 15.62 per cent.
21. In a classification of the epitheliomas according to cellular activity, graded 1 to 4, Grade 1 represents 8.20 per cent.; Grade 2, 69.53 per cent.; Grade 3, 17.18 per cent., and Grade 4, 5.07 per cent.
22. The average duration of the lesion according to grade was longest

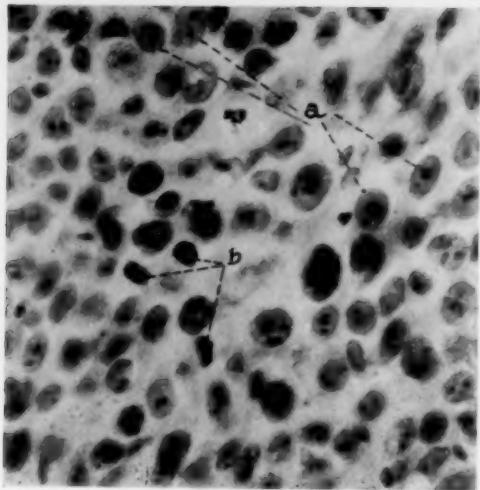


FIG. 13 (Case A38629).—Very malignant area of a Grade 3 epithelioma; *a*, "one-eyed cells"; *b*, mitotic figures. In some areas in this neoplasm the cells showed a tendency to differentiate.

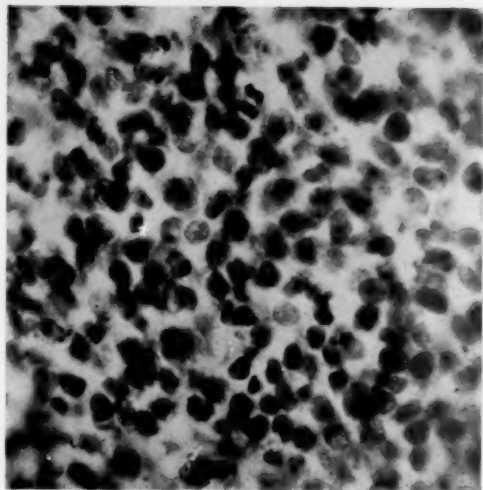
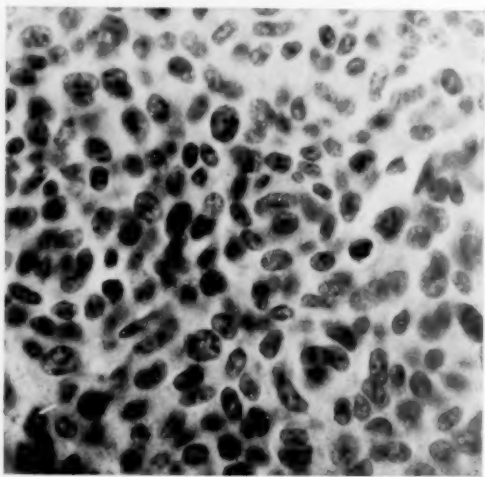
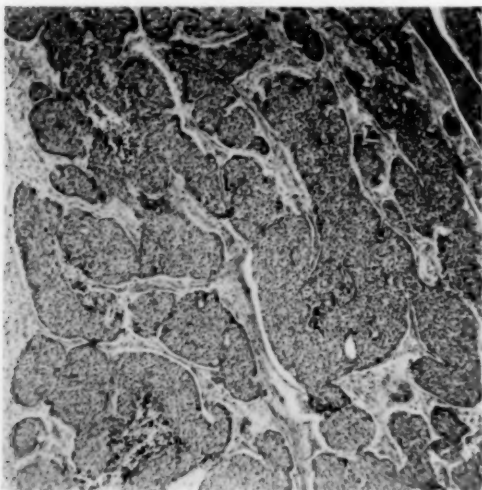


FIG. 16 (Case A118133).—High-power magnification of Grade 4 epithelioma similar to epithelioma shown in Fig. 15.



FIGS. 14 AND 15 (Case A90864).—Low-power and high-power magnification of a Grade 4 epithelioma, showing irregular pale-staining cells; very few one-eyed cells.

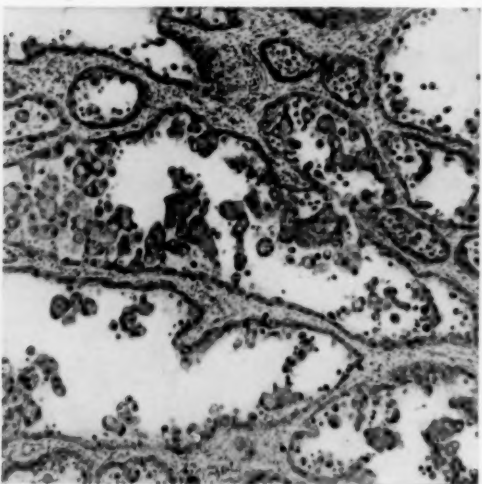


FIG. 17 (Case A56882).—Squamous-cell epithelioma of the skin, showing a number of cells undergoing keratinization (low power).

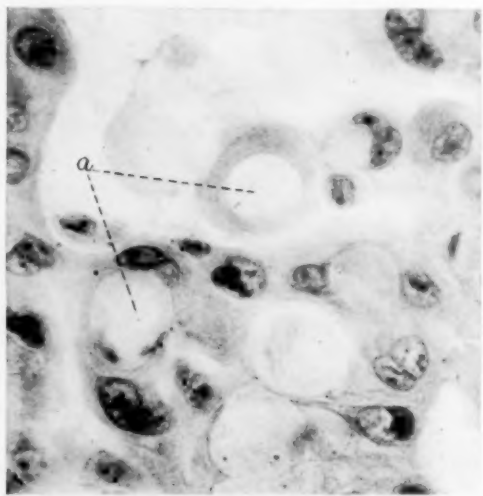


FIG. 18 (Case A56882).—High-power magnification of section shown in Fig. 17; *a*, cells becoming keratinized.

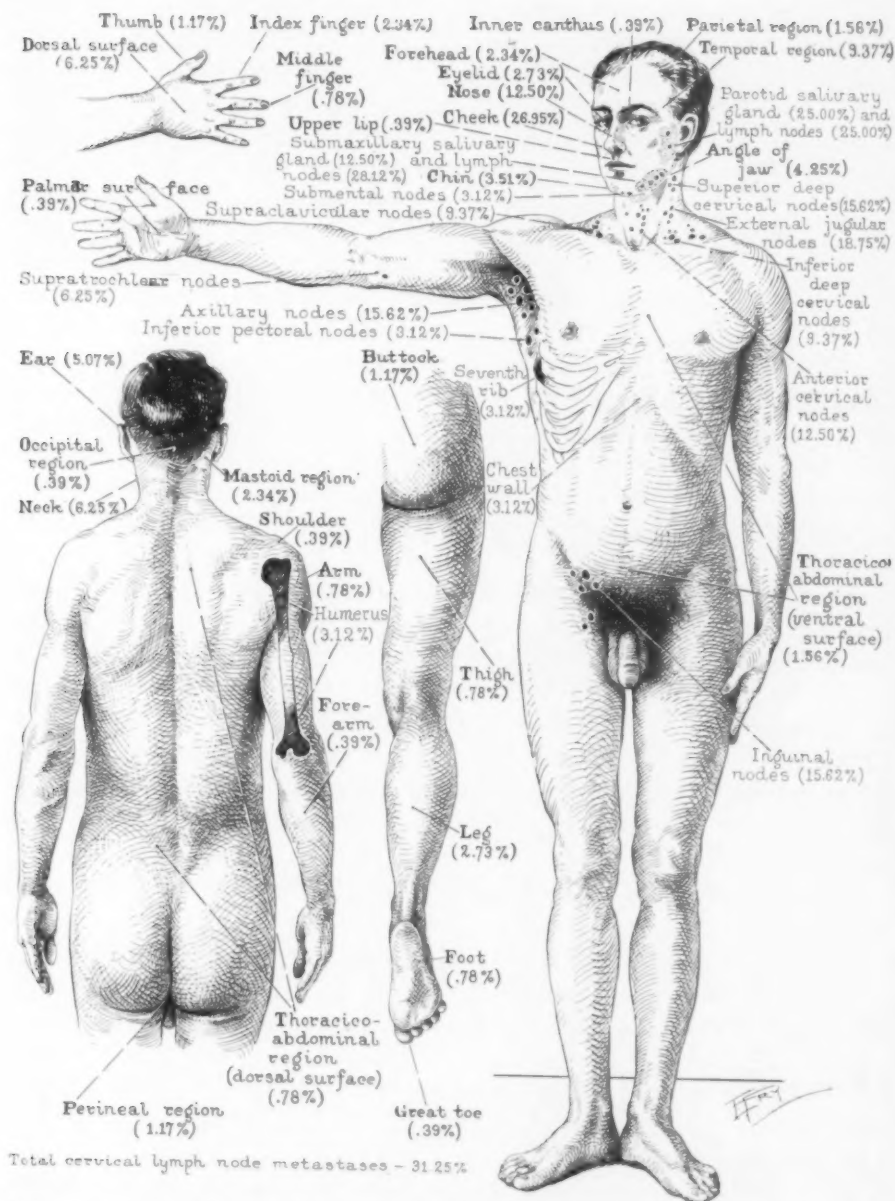


FIG. 19.—Percentages of points of origin in squamous-cell epithelioma of the skin and percentages of location of metastasis (location, dark letters; metastasis light letters).

in Grade 2, five and thirty-six hundredths years, and shortest in Grade 3, three and two hundredths years.

23. The average size of the lesion according to grade was largest in Grade 4, 5.4 cm., and smallest in Grade 1, 2.09 cm.

24. Fifty-one and seventy-seven hundredths per cent. of the patients operated on and traced are dead and 48.22 per cent. are alive.

25. Eighty-two and thirty-five hundredths per cent. of the living patients report good results, having been free from the disease on an average of seven and forty-four hundredths years.

26. Information received concerning the patients operated on who died, shows that 65.51 per cent. died of epithelioma.

27. Three (1.27 per cent.) of the patients who were operated on died before being dismissed from the Clinic; the actual operative mortality was 0.42 per cent.

28. Patients who were treated with pastes, plasters, and so forth, before entering the Clinic did not get such good total good results as those who were not so treated, 57.14 per cent. in the former group and 61.11 per cent. in the latter; the total poor results were 40 per cent. in the former group and 30 per cent. in the latter.

29. Ten and fifty-two hundredths per cent. of the patients with metastasis are living.

30. One of the two living patients who had metastasis reports a good result and one a fair result. In these patients the parotid lymph-nodes and salivary gland on one side only were involved.

31. No patient with cervical lymph-nodes or more than one group of any lymph-nodes involved has been reported living.

32. All the patients reported dead who had metastasis died of epithelioma.

33. Sixty per cent. of the patients operated on in whom no metastasis was demonstrated are living, all with good results, and 40 per cent. are dead.

34. Sixty-six and sixty-six hundredths per cent. of the patients reported dead who did not have metastasis died of epithelioma.

35. Fifty-three and fifteen hundredths per cent. of the patients operated on in whom no regional lymph-nodes or salivary glands were removed are living and 46.84 per cent. are dead; 81.35 per cent. of the living report good results

36. Fifty-four and seventy-six hundredths per cent. of the patients reported dead in whom no regional lymph-nodes or salivary glands were removed, died of epithelioma.

37. The total good results for the patients with metastasis are 6.66 per cent.; for those without metastasis, 77.77 per cent.; and for those in whom no regional lymph-nodes or salivary glands were removed, 66.33 per cent.

38. The total poor results without regard to grade for the patients with metastasis are 86.66 per cent.; for those without metastasis, 22.22 per

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cent.; and for those in whom no regional lymph-nodes or salivary glands were removed, 25.74 per cent.

39. The average duration of the lesion in the patients with metastasis was two and sixty-seven hundredths years; in those without metastasis, five and three hundredths years; and in those in whom no regional lymph-nodes or salivary glands were removed, four and seventy-eight hundredths years.

40. The average size of the lesion in the patients with metastasis was 6.3 cm.; in those without metastasis, 4.15 cm.; and in those in whom no regional lymph-nodes or salivary glands were removed, 3.08 cm.

41. The known causes of deaths from epithelioma were: Grade 1, 0; Grade 2, 61.29 per cent.; Grade 3, 85.71 per cent.; and Grade 4, 100 per cent.

42. The total good results for Grade 1 are 92.85 per cent.; Grade 2, 65.43 per cent.; Grade 3, 41.66 per cent.; and Grade 4, 0.

43. The total poor results for Grade 1 are 0; Grade 2, 25.92 per cent.; Grade 3, 54.16 per cent.; and Grade 4, 100 per cent.

TABLE I

*Squamous-cell Epithelioma of the Skin: Two Hundred and Fifty-six Cases (12.8 Per Cent. of Two Thousand Cases of General Epithelioma) from November 1, 1904, to July 22, 1915, Mayo Clinic.*

	No.	Per Cent.
Patients .....	256	
Males .....	205	80.078
Females .....	51	19.921
Age:		
Youngest patient .....		25.
Oldest patient .....		88.
Average age of patients .....		59.34
Occupation (males):		
Farmer .....	102	53.96*
Laborer .....	21	11.11
Merchant .....	11	5.81
Railroad employee .....	8	4.23
Physician: .....	6	3.17
Agent .....	4	2.11
Other occupations, 22 each under 2 per cent. ....	37	19.57
Family history of malignancy .....	31	12.10
Previous lesion at site of cancer:		
Mole, wart, pimple, scab, ulcer, leucoplakia, crack, wen, blister, lump, etc. ....	131	51.17
History of injury .....	61	23.82
Burns, proportion of total injuries .....	15	24.59
X-ray burns, proportion of total burns .....	3	20.00
Average duration of lesion .....	4.8	years
Longest duration of lesion .....	35.0	years
Shortest duration of lesion .....	0.057	year
Geatest diameter .....	30.00	cm.
Average greatest diameter .....	3.854	cm.

\*A large proportion of patients coming to the Mayo Clinic are from rural communities.

ALBERT COMPTON BRODERS

TABLE II

*Location of the Lesion (Fig. 19)*

	Cases	Per Cent.
Single lesion .....	247	96.48
Multiple lesions .....	9	3.51
Cheek .....	69	26.95
Nose .....	32	12.50
Temporal region .....	24	9.37
Neck .....	16	6.25
Hand (dorsal surface) .....	16	6.25
Ear .....	13	5.07
Angle of jaw .....	11	4.25
Chin .....	9	3.51
Eyelid .....	7	2.73
Leg .....	7	2.73
Forehead .....	6	2.34
Mastoid region .....	6	2.34
Index finger .....	6	2.34
Thoracico-abdominal region (ventral surface) .....	4	1.56
Parietal region .....	4	1.56
Thumb .....	3	1.17
Buttock .....	3	1.17
Perineal region .....	3	1.17
Thoracico-abdominal region (dorsal surface) .....	2	0.78
Arm .....	2	0.78
Middle finger .....	2	0.78
Thigh .....	2	0.78
Foot .....	2	0.78
Inner canthus .....	1	0.39
Occipital region .....	1	0.39
Upper lip (near nose) .....	1	0.39
Shoulder .....	1	0.39
Forearm .....	1	0.39
Hand (palmer surface) .....	1	0.39
Great toe .....	1	0.39

TABLE III

*Treatment Elsewhere of Squamous-cell Epithelioma of the Skin*

Non-surgical:

	No.	Per Cent.
One or more treatments with acids (carbolic, chromic, hydrochloric and nitric), alum (burnt), carbon dioxide, electricity, paste, potassium iodide, radium, Röntgen-ray (proportion of total non-operative methods of treatment, 50 per cent.) scarlet red and silver nitrate ....	72	28.12

Surgical:

One or more operations .....	69	26.95
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Surgical and non-surgical:

Operations without treatment with acids, alum, carbon dioxide, etc... ..	50	19.53
Treatment with acids, alum, carbon dioxide, etc., without operation ....	53	20.70
Operation and treatment with acids, alum, carbon dioxide, etc. ....	103	40.23

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TABLE IV

*Patients Operated on at the Mayo Clinic*

Number of patients .....	236	(92.18 per cent. of 256)
Excision with knife immediately followed by cautery (one operation) .....	52	(22.03 per cent. of 236)
Excision with knife (one operation) .....	46	(19.49 per cent. of 236)
Block dissection of neck (unilateral) either alone or combined with other operations or methods of treatment before, at the same time, or after the block dissection was performed .....	9	(3.81 per cent. of 236)
Cautery (one operation) .....	8	(3.38 per cent. of 236)
Excision with cautery (one operation) .....	7	(2.96 per cent. of 236)
Excision with knife immediately followed by cautery (one operation) and later by skin graft (one operation) .....	7	(2.96 per cent. of 236)
Amputation of one or more fingers or of thumb and removal of regional lymph-nodes at the time of amputation or after amputation and either associated with or not associated with other operative or non-operative treatment before, at the time of, or after amputation..	6	(2.54 per cent. of 236)
Amputation of thigh or leg with or without removal of regional lymph-nodes and either associated or not associated with other operative or non-operative treatment before, at the time of, or after amputation .....	5	(2.11 per cent. of 236)
Amputation of arm, forearm, or hand with removal of regional lymph-nodes before or at the time of amputation, and either associated or not associated with other operative or non-operative treatment before, at the time of, or after the amputation .....	5	(2.11 per cent. of 236)
Excision with knife immediately followed by cautery (one operation) and followed later by cautery (one operation) .....	4	(1.69 per cent. of 236)
Cautery (two operations) .....	4	(1.69 per cent. of 236)
Block dissection of neck (bilateral) (two operations) accompanied by a complete evisceration of the left eye, excision of eyelids, and one supraclavicular lymph-node preceded by three excisions with knife immediately followed by cautery .....	1	(0.423 per cent. of 236)
Miscellaneous (various combinations of operations, radium and Röntgen-rays) .....	82	(34.74 per cent. of 236)
Inoperable .....	16	(6.25 per cent. of 236)
Operation refused after diagnosis had been made .....	4	(1.56 per cent. of 236)
Cases in which no lymph-nodes or salivary glands were removed .....	184	(77.96 per cent. of 236)
Cases in which lymph-nodes or salivary glands were removed (one or more groups) .....	52	(22.03 per cent. of 236)

TABLE V

*Lymph-nodes and Salivary Glands Removed in Fifty-two Cases*

	Cases	Per Cent.
Submaxillary lymph-nodes .....	23	44.23
Submaxillary salivary glands .....	23	44.23
External jugular-nodes .....	20	38.46
Superior deep cervical-nodes .....	15	28.84
Anterior cervical-nodes .....	12	23.07
Inferior deep cervical-nodes .....	12	23.07
Cervical lymph-nodes .....	21	40.38
Parotid salivary gland .....	10	19.21
Parotid lymph-nodes .....	9	17.30
Submental-nodes .....	9	17.30
Axillary-nodes .....	9	17.30
Inguinal-nodes .....	6	11.53
Supratrochlear-nodes .....	3	5.76
Supraclavicular lymph-nodes .....	3	5.76
Chest wall .....	1	1.92

TABLE VI

*Pathologic Findings in Fifty-two Cases in which Lymph-nodes and Salivary Glands Were Removed*

	Cases	Per Cent.
No metastasis .....	20	38.46
Metastasis .....	32	61.53
Inguinal lymph-nodes alone (one side) .....	5	15.62
Axillary lymph-nodes alone (one side) .....	3	9.37
Parotid salivary gland and lymph-nodes (one side) .....	5	15.62
Submaxillary lymph-nodes alone (one side) .....	2	6.25
Submaxillary salivary gland and lymph-nodes (one side) .....	2	6.25
Right and left external jugular, submental, left submaxillary and supraclavicular lymph-nodes .....	1	3.12
External jugular, anterior cervical, superior and inferior deep cervical lymph-nodes (one side) .....	1	3.12
Supratrochlear and axillary lymph-nodes, lower and upper end of humerus, chest wall including seventh rib, axillary line (one side). .....	1	3.12
Miscellaneous (submaxillary lymph-nodes and salivary glands, parotid lymph-nodes and salivary glands, cervical, supraclavicular, supra-trochlear, axillary, and inferior pectoral lymph-nodes, alone or in various combinations (one side) .....	12	37.50

# SQUAMOUS-CELL EPITHELIOMA OF THE SKIN

TABLE VII

*Metastasis in Thirty-two Cases (Fig. 19)*

	Cases	Per Cent.
Submaxillary lymph-nodes .....	9	28.12
Parotid lymph-nodes .....	8	25.00
Parotid salivary gland .....	8	25.00
External jugular lymph-nodes .....	6	18.75
Superior deep cervical lymph-nodes .....	5	15.62
Axillary lymph-nodes .....	5	15.62
Inguinal lymph-nodes .....	5	15.62
Submaxillary salivary gland .....	4	12.50
Anterior cervical lymph-nodes .....	4	12.50
Inferior deep cervical lymph-nodes .....	3	9.37
Supraclavicular lymph-nodes .....	3	9.37
Supratrochlear lymph-nodes .....	2	6.25
Submental lymph-nodes .....	1	3.12
Inferior pectoral lymph-nodes .....	1	3.12
Chest wall .....	1	3.12
Lower and upper ends of humerus .....	1	3.12
Seventh rib, axillary line .....	1	3.12
Cervical lymph-node involvement .....	10	31.25

TABLE VIII

*Grades in 256 Cases on a Basis of 1 to 4 According to Cellular Activity*

	Cases	Per Cent.
Grade 1 .....	21	8.20
Grade 2 .....	178	69.53
Grade 3 .....	44	17.18
Grade 4 .....	13	5.07

## *Duration and Size of Epithelioma*

	Grade 1 Years	Grade 2 Years	Grade 3 Years	Grade 4 Years
Longest duration .....	20.00	35.00	10.00	20.00
Shortest duration .....	0.08	0.05	0.16	0.10
Average duration .....	4.76	5.36	3.02	3.30
	Cm.	Cm.	Cm.	Cm.
Largest size .....	4.30	30.00	14.00	15.00
Smallest size .....	0.50	0.30	1.20	0.60
Average size .....	2.09	3.70	4.61	5.40
	Grade 1	Grade 2	Grade 3	Grade 4
Operable epithelioma .....	21	164	39	12
Inoperable epithelioma .....	0	11	4	1
	Grade 1	Grade 2	Grade 3	Grade 4
Operation refused after diagnosis had been made .....	0	3	1	0

# ALBERT COMPTON BRODERS

TABLE IX

## General Ultimate Results

Patients traced (operable, 141; inoperable, 5; refused operation, 1) .....	147	(57.42 per cent. of 256)
Patients operated on .....	141	
Patients living .....	68	(48.22 per cent.)
Good result .....	56	(82.35 per cent. of 68)
Fair result .....	9	(12.23 per cent. of 68)
Poor result .....	3	(4.41 per cent. of 68)

## Duration of Life Since Last or Only Operation

	Good result Years	Fair result Years	Poor result Years
Longest .....	13.16	12.05	5.23
Shortest .....	4.31	5.50	0.15
Average .....	7.44	8.78	3.28
Patients dead .....	73	(51.77 per cent.)	

## Deaths

Patients .....	79	(53.74 per cent. of 147)
Patients with operable epithelioma .....	73	(92.40 per cent. of 79)
Patients with inoperable epithelioma .....	5	(6.32 per cent. of 79)
Patients who refused operation after diagnosis had been made .....	1	(1.26 per cent. of 79)

## Cause of Death of Patients Operated on: Data from Relative, Home Physician, or Pathologic Records of the Clinic

	No.	Per Cent.
Known cause .....	58	
Epithelioma .....	38	65.51
Old age .....	4	6.89
Heart disease .....	4	6.89
Paralysis .....	3	5.17
Pneumonia .....	2	3.44
Arteriosclerosis .....	1	1.72
Acute gastritis .....	1	1.72
Carcinoma of pancreas .....	1	1.72
General infection .....	1	1.72
Carcinoma of prostate and pneumonia .....	1	1.72
Influenza .....	1	1.72
Tuberculosis .....	1	1.72
Unknown .....	15	

## Cause of Death of Patients Operated on Who Died at the Clinic

Epithelioma and pneumonia (1.28 years after operation) ..	1	
Carcinoma of prostate and pneumonia (0.47 years after operation) .....	1	
Epithelioma and shock (0.027 year after operation) .....	1	
Total .....	3	(1.27 per cent. of 236)
Actual operative mortality .....	1	(0.42 per cent. of 236)

# SQUAMOUS-CELL EPITHELIOMA OF THE SKIN

TABLE X

*Patients Operated on, Treated with Pastes, Plasters, Acids, Etc., Before Entering the Clinic*

Information received.....	Grade 1	Grade 2	Grade 3	Grade 4	
Patients living.....					36 (54.54 per cent. of 66)
Good result.....	2 (10.52 per cent. of 19)	14 (73.68 per cent. of 19)	3 (15.78 per cent. of 19)		21 (58.33 per cent. of 36)
Fair result.....	1 (100 per cent. of 1)				
Poor result.....			1 (100 per cent. of 1)		
Patients dead.....					15 (41.66 per cent. of 36)
Good result.....	1 (100 per cent. of 1)				
Poor result.....	9 (69.23 per cent. of 13)	3 (23.07 per cent. of 13)	1 (7.69 per cent. of 13)		
Cause unknown.....	1				
<i>Total Results</i>					
Good (patients recovered from epithelioma and are living or recovered from epithelioma and died of other cause).....					20 (57.14 per cent. of 35)
Fair (patient living with slight recurrence).....					1 (2.85 per cent. of 35)
Poor (patients living with no improvement or died of epithelioma).....					14 (40.00 per cent. of 35)
No information received.....					30 (45.45 per cent. of 66)

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TABLE XI

*Patients Operated on, Not Treated with Pastes, Plasters, Acids, Etc., Before Entering the Clinic*

Information received.....	Grade 1	Grade 2	Grade 3	Grade 4	
Patients living.....					104 (61.17 per cent. of 170)
Good result.....	4 (11.11 per cent. of 36)	27 (75 per cent. of 36)	5 (13.88 per cent. of 36)		46 (44.23 per cent. of 104)
Fair result.....	2 (25.00 per cent. of 8)	5 (62.50 per cent. of 8)	1 (12.50 per cent. of 8)		
Poor result.....		2 (100 per cent. of 2)			
Patients dead.....					58 (55.76 per cent. of 104)
Good result.....	6 (31.57 per cent. of 19)	11 (57.89 per cent. of 19)	2 (10.52 per cent. of 19)		
Poor result.....	11 (44.00 per cent. of 25)	8 (32.00 per cent. of 25)	6 (24.00 per cent. of 25)		
Cause unknown.....	2				
<i>Total Results</i>					
Good (patients recovered from epithelioma and are living, or recovered from epithelioma and died of other causes).....					55 (61.11 per cent. of 90)
Fair (patients living with slight recurrence).....					8 (8.88 per cent. of 90)
Poor (patients living with no improvement or died of epithelioma).....					27 (30.00 per cent. of 90)
No information received.....					66 (38.82 per cent. of 170)

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TABLE XII  
*Patients with Metastasis Operated on with Removal of Regional Lymph-nodes or Salivary Glands*

Information received.....	Grade 2	Grade 3	Grade 4	
Patients living.....				19 (59.37 per cent. of 32)
Good result.....	1 (100 per cent. of 1)			
Fair result.....		1 (100 per cent. of 1)		2 (10.52 per cent. of 19)
Patients dead.....				17 (89.47 per cent. of 19)
Poor result.....	4 (30.76 per cent. of 13)	4 (30.76 per cent. of 13)	5 (38.46 per cent. of 13)	
Cause unknown.....	2	2		
<i>Total Results</i>				
Good (patient recovered from epithelioma).....				1 ( 6.66 per cent. of 15)
Fair (patient living with slight recurrence).....				1 ( 6.66 per cent. of 15)
Poor (patients died of epithelioma).....				13 (86.66 per cent. of 15)
<i>Cause of Death</i>				
Epithelioma.....				13 (100 per cent. of 13)
No information received.....				13 (40.62 per cent. of 32)
* In the patient who reported a good result and in the one who reported a fair result, the parotid lymph-nodes and salivary glands on only one side were involved.				

TABLE XIII  
*Patients Without Metastasis Operated on With Removal of Regional Lymph-nodes or Salivary Glands*

Information received.....	Grade 1	Grade 2	Grade 3	
Patients living.....				10 (50 per cent. of 20)
Good result.....	2 (33.33 per cent. of 6)	3 (50.00 per cent. of 6)	1 (16.66 per cent. of 6)	6 (60 per cent. of 10)
Patients dead.....				4 (40.00 per cent. of 10)
Good result.....	1 (100 per cent. of 1)	1 (100 per cent. of 1)		
Poor result.....		2 (100 per cent. of 2)		
Cause unknown.....		1		
<i>Total Results</i>				
Good (patients recovered from epithelioma and are living or recovered from epithelioma and died of other cause).....				7 (77.77 per cent. of 9)
Poor (patients died of epithelioma).....				2 (22.22 per cent. of 9)
<i>Cause of Death</i>				
Epithelioma.....				2 (66.66 per cent. of 3)
Heart disease.....				1 (33.33 per cent. of 3)
No information received.....				10 (50.00 per cent. of 20)

# SQUAMOUS-CELL EPITHELIOMA OF THE SKIN

TABLE XIV  
*Patients Operated on Without Removal of Regional Lymph-nodes or Salivary Glands*

Information received.....	Grade 1	Grade 2	Grade 3	Grade 4	
Patients living.....					111 (60 per cent. of 185)
Good result.....	5 (10.41 per cent. of 48)	35 (75.00 per cent. of 48)	7 (14.58 per cent. of 48)		59 (53.15 per cent. of 111)
Fair result.....	1 (12.50 per cent. of 8)	7 (87.50 per cent. of 8)			
Poor result.....		2 (66.66 per cent. of 3)	1 (33.33 per cent. of 3)		
Patients dead.....					52 (46.84 per cent. of 111)
Good result.....	7 (36.84 per cent. of 19)	10 (52.63 per cent. of 19)	2 (10.52 per cent. of 19)		
Poor result.....		14 (60.86 per cent. of 23)	7 (30.43 per cent. of 23)	2 (8.69 per cent. of 23)	
Cause unknown.....	2	8			
<i>Total Results</i>					
Good (patients recovered from epithelioma and are living or recovered from epithelioma and died of other cause)					67 (66.33 per cent. of 101)
Fair (patients living with slight recurrence)					8 (7.92 per cent. of 101)
Poor (patients living with no improvement or died of epithelioma)					26 (25.74 per cent. of 101)
<i>Cause of Death</i>					
Epithelioma.....					23 (54.76 per cent. of 42)
Old age.....					4 (9.52 per cent. of 42)
Paralysis.....					3 (7.14 per cent. of 42)
Heart disease.....					3 (7.14 per cent. of 42)
Pneumonia.....					2 (4.76 per cent. of 42)
Acute gastritis.....					1 (2.38 per cent. of 42)
Arteriosclerosis.....					1 (2.38 per cent. of 42)
Carcinoma of pancreas.....					1 (2.38 per cent. of 42)
Carcinoma of prostate and pneumonia.....					1 (2.38 per cent. of 42)
General infection.....					1 (2.38 per cent. of 42)
Influenza.....					1 (2.38 per cent. of 42)
Tuberculosis.....					1 (2.38 per cent. of 42)
No information received.....					74 (40.00 per cent. of 185)

TABLE XV  
*Patients With Metastasis and Patients Without Metastasis Operated on and Patients in Whom no Regional Lymph-nodes or Salivary Glands Were Removed*

	Grade 1	Grade 2	Grade 3	Grade 4
With metastasis.....	11 (34.2 per cent. of 32)	12 (37.5 per cent. of 32)	9 (28.12 per cent. of 32)	
Without metastasis.....	2 (10 per cent. of 20)	4 (20.00 per cent. of 20)		
Without removal of regional lymph-nodes or salivary glands.....	19 (10.32 per cent. of 184)	139 (75.64 per cent. of 184)	23 (12.5 per cent. of 184)	3 (1.63 per cent. of 184)
<i>Duration of Lesion Before Patient's Examination at the Clinic</i>				
With metastasis.....	Longest, 15 years	Shortest, 0.10 year	Average, 2.67 years	
Without metastasis.....	Longest, 20 years	Shortest, 0.8 year	Average, 5.3 years	
Without removal of regional lymph-nodes or salivary glands.....	Longest, 35 years	Shortest, 0.05 year	Average, 4.78 years	
<i>Size of Lesion at the Time of Patient's Examination at the Clinic</i>				
With metastasis.....	Largest, 30 cm.	Smallest, 1.5 cm.	Average, 6.3 cm.	
Without metastasis.....	Largest, 15 cm.	Smallest, 1.5 cm.	Average, 4.15 cm.	
Without removal of regional lymph-nodes or salivary glands.....	Largest, 30 cm.	Smallest, 0.3 cm.	Average, 3.08 cm.	

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Information received.....					
Patients living.....					
Good result.....	1	1			2
Fair result.....	1				11.8 years
Patients dead.....					12
Poor result.....	4		3	5	
		Years	Years	Years	Average of all grades
Longest.....		1.28	0.50	2.96	2.96
Shortest.....		0.15	0.31	0.027	0.027
Average.....		0.68	0.41	1.58	0.98
No information received.....					18 (46.25 per cent. of 32)

# SQUAMOUS-CELL EPITHELIOMA OF THE SKIN

TABLE XVII  
*Duration of Life After Operation of Twenty Patients Without Metastasis*

Information received.....	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Average of all Grades
Patients living.....	2	3	1			6	Years
Good result.....	2	3	1			6	Years
Longest.....	7.26	7.97	8.90				8.90
Shortest.....	6.01	6.33					6.01
Average.....	6.63	7.18					7.29
Patients dead.....						2	
Good result.....		1					
Poor result.....		1					
Longest.....		1.33					1.33
Shortest.....		0.37					0.37
Average.....		0.85					0.85
No information received.....						12 (60.00 per cent. of 20)	

TABLE XVIII  
Duration of Life of Patients Operated on Without Removal of Regional Lymph-nodes or Salivary Glands

	Grade 1	Grade 2	Grade 3
Patients living:			
Good result.....	5 Years	37 Years	7 Years
Longest.....	6.49	13.14	10.88
Shortest.....	4.93	4.31	6.04
Average.....	5.70	7.74	7.59
Fair results.....	1	7	
Longest.....	1.59	12.50	
Shortest.....		5.50	
Average.....		8.38	
Poor result.....		2	1
Longest.....		5.23	0.15
Shortest.....		4.46	
Average.....		4.84	
Patients living:			
Longest.....		13.14 years	
Shortest.....		4.31 years	
Average.....		7.51 years	
Patients dead (not of epithelioma).....		6 years	
Good result			
Longest.....		8.16 years	
Shortest.....		0.43 year	
Average.....		3.96 years	
Poor result.....		13 years	
Longest.....		3.61 years	
Shortest.....		0.26 year	
Average.....		1.45 years	
Average of all grades			0.93 year
Average of all grades			0.78 year
Average of all grades			0.61 year
Average of all grades			0.05 year
Average of all grades			2.45 year

# SQUAMOUS-CELL EPITHELIOMA OF THE SKIN

TABLE XIX  
Results Following Operation

	Grade 1		Grade 2		Grade 3		Grade 4	
Information received.....	16	(76.19 per cent. of 21)	92	(56.09 per cent. of 164)	26	(66.66 per cent. of 39)	7	(58.33 per cent. of 12)
Patients living.....	8	(50.00 per cent. of 16)	50	(54.34 per cent. of 92)	10	(38.46 per cent. of 26)		
Good result.....	7	(87.50 per cent. of 8)	41	(82.00 per cent. of 50)	8	(80.00 per cent. of 10)		
Poor result.....	1	(12.50 per cent. of 8)	7	(14.00 per cent. of 50)	1	(10.00 per cent. of 10)		
Patients dead.....	8	(50.00 per cent. of 16)	2	(4.00 per cent. of 50)	1	(10.00 per cent. of 10)		
Good result.....	6	(100 per cent. of 6)	42	(45.65 per cent. of 92)	16	(61.53 per cent. of 26)	7	(100 per cent. of 7)
Poor result.....			12	(38.70 per cent. of 31)	2	(14.28 per cent. of 14)		
Not stated.....	2		19	(61.29 per cent. of 31)	12	(85.71 per cent. of 14)	7	(100 per cent. of 7)
Total good result (patients re-covered from epithelioma and are living or recovered from epithelioma and died of other cause) 13	(92.85 per cent. of 15)	53	(65.43 per cent. of 81)	10	(41.66 per cent. of 24)			
Total fair result (patients living with slight recurrence).....	1 (7.14 per cent. of 14)	7	(8.64 per cent. of 81)	1	(4.16 per cent. of 24)			
Total poor result (patients living with no improvement or died of epithelioma).....		21	(25.92 per cent. of 81)	13	(54.16 per cent. of 24)	7	(100 per cent. of 7)	
Total result not stated.....	2	11		2				

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## PAINLESS HYPODERMOCLYSIS

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THE vicarious administration of water has been revolutionized in my service by the employment of local anæsthesia from the beginning to the end of the procedure. It seems remarkable, in view of the perfection of local anæsthesia technic everywhere in minor surgery, that we have been content with a hypodermoclysis which must in most instances have seemed to the patient little short of brutal.

Sporadic attempts have been made to minimize the discomfort attending some of the steps in the operation, but I submit herewith a technic which has on many occasions worked so well that the patient has not at any time paid the slightest attention to the introduction of comparatively large amounts of water. I will grant in passing that nothing is claimed in the rare instances where nervous patients, objecting to local anæsthesia in any form, have forcibly opposed its use.

A very extensive employment of infiltration anæsthesia led to the suggestion of introducing very *dilute novocaine* where we had been in the habit of using straight salt solution, or what may be better, distilled water. This came about quite naturally after using in a very few instances abnormally large quantities of  $\frac{1}{2}$  per cent. novocaine solution, and reflecting that the introduction of a few 100 c.c. of fluid into a partially dehydrated patient had to some extent offset the possible risk of employing what may well be considered a toxic dose of the novocaine which seemed indispensable to the performance of a much-needed surgical operation.

I will state in passing that I have never observed dangerous toxic symptoms following the employment of novocaine, although I have frequently far exceeded what is commonly given as the maximum dose. In the evolution of this method we gave as hypodermoclysis gradually increasing amounts of fluids, in which from time to time the percentage of novocaine was cut down first from  $\frac{1}{2}$  to  $\frac{1}{4}$ , then to  $\frac{1}{8}$ , and finally to  $\frac{1}{16}$  of 1 per cent., without the anæsthetic value of the drug being appreciably diminished. I am perfectly well aware that so distinguished an authority as Braun writes that he has never been able to use novocaine successfully in a concentration as low as  $\frac{1}{4}$  of 1 per cent. This has not, however, been in accordance with my own experience, or that of Allen, Farr, Wennerman, *et al.*, who are making very extensive use of this substance. Now I do not wish to be understood as advocating  $\frac{1}{8}$  or  $\frac{1}{16}$  per cent. novocaine solution in the performance of surgical operations, but this I can state conclusively that it suffices for the introduction of fluid under the skin.

It was but a further step in the technic to add sterile morphine to the hypodermoclysis fluid. Many a patient requires this drug for the same

manifestations which indicate hypodermoclysis, and surely the morphine effect is an aid in combating any possible discomfort attending the introduction of fluid under the skin. The dosage is, of course, to be determined by the rapidity of inflow, age and condition of the patient, and all the other elements which ordinarily enter into the employment of this, to the surgeon, valued drug.

Where hypodermoclysis is used in any of the conditions, such as shock, hemorrhage, etc., which are attended by a fall of blood-pressure, we are accustomed to add adrenalin to the fluid. A constant inflow of this substance is highly desired, since its destruction is so rapid as to make the effect of each small dose of short duration.

The use of freshly distilled water, instead of salt solution in my service, commenced in 1915, at the suggestion of my then house surgeon, Dr. O. F. McKittrick. It occurred to him that the introduction of sodium chloride solution in large amounts led to an undesirable salt concentration in the body. He experimented in every way, after discussing any possible risk of employing water, with Doctor Erlanger, and obtained most gratifying results. By comparing water and salt solution introduced at the same time in the two axillæ of the same individual he found that water was absorbed more rapidly than the other fluid. He used as high as 10,000 c.c. in three days and in only a few instances noted a drawback which might have happened if salt solution had been used, *viz.*, an extensive imbibition of the subcutaneous tissues took place in jaundiced individuals.

The choice of a method of vicariously administering fluid becomes a matter of even greater importance perhaps than was formerly supposed, to one who reads the astonishing results obtained by Balcar, Sansun and Woodyatt in their article entitled "Fever and the Water Reserve of the Body," which appears in the *Archives of Internal Medicine* for July, 1919. As they suggest, no doubt salts do hold water in association with themselves, which may be an argument for the administering of sterile water instead of salt solution under the skin. However this may be, I am not at all sure that sterile water, which is not an *isotonic* material, can always be used without undesirable local effects. On many occasions, as above noted, it has served me well, but at other times its use has been followed by tissue changes, which, however, it is only fair to state in comparison, one occasionally sees when salt solution is employed. In this connection, I am glad to be able to quote verbatim a communication received recently from Dr. Evarts A. Graham: "For some time I have been using glucose solutions hypodermically in concentration of from 2 to 5 per cent. A solution of about 3 per cent. is nearly isotonic with the blood, and, as a matter of fact, it is possible to exceed this amount considerably without damage, because of the rapid disappearance of the glucose in the tissues. Glucose solutions hypodermically have a decided advantage over ordinary saline solutions because, in the first place, glucose is, of course, a food which is readily utilized by the body; in the second place, glucose is a very efficient anti-ketogenic substance so that it is of great value in combating any existing acidosis which is usually present to some degree

## PAINLESS HYPODERMOCLYSIS

in conditions which require the injection of fluids, such as post-operative conditions of all kinds, infections, inanition, etc.; in the third place, such a solution has the decided advantage of liberating 'free' water gradually to the tissues as the glucose is burned by the body."

The apparatus we use is simplicity itself, consisting of the ordinary 700 c.c. glass drip bottle, a rubber tube one yard in length, controlled by a screw clamp, and a slender, long needle. This is substantially the apparatus commonly used by hospitals for the introduction of water into the rectum, with the exception that we have, for use, cut out the drop sight feed attachment, since we make use of a local anæsthesia agent, and the rate of inflow into desensitized tissues does not matter particularly. The inflow is regulated according to the rate of absorption, the water-logged area never being allowed to become unreasonably tight, and thus threaten tissue pressure necrosis. The needle sometimes has to be withdrawn, cleaned out with a wire and reinserted if it becomes plugged.

We find the flank midway between the lower ribs and the prominent upper curve of the ilium to be the site of election, since less subsequent damage has occurred here than elsewhere. We no longer inject fluid under the breast of a woman, because she is likely to experience a great deal of pain every time she takes a breath for some hours after the anæsthesia effect of the fluid has worn off. The same thing is true with movement of the upper arm if a fluid has been injected about the axillæ or the pectoral muscles. Furthermore, the cavity of the axilla contains structures which are by no means indifferent to a long needle, wielded by an inexperienced nurse or a careless interne. If worst comes to worse, and the avoidable as well as inexcusable accidental infection occurs, this is distinctly more to be dreaded in either of the three regions enumerated than it is under the skin of the flank, where surgical treatment is a comparatively simple matter.

The introduction of the needle is made painless by an ethyl chloride spray on the skin. After the needle has been introduced, the region is covered by a small square of gauze, held in place with adhesive, and the surgical aspect of the little procedure is complete. Then it remains only for a nurse, or the patient himself, if he be a very reasonable individual, to control the rate of inflow.

In some few instances the ordinary sight drip apparatus has been employed, and forty to eighty drops admitted per minute, but any form of graduated clamp may be used and opened or closed at will. It may be noted in passing, that plethora is a possibility here, and a patient who is receiving large amounts of fluid should be examined occasionally for evidences of cardiac dilatation or pulmonary œdema.

Our three vital bodily needs are oxygen, with which we cannot dispense for more than a few minutes; water, which we can go without for a few hours, and food for which an urgent need becomes apparent after a few days. These three essentials to a vegetative existence are of such paramount importance that a little more detailed discussion of water in its relation to the human organism cannot fail to be of interest. An intake and output record

must be kept wherever there is any difficulty about the ingestion of fluids or any great alteration in its output. This goes without saying in the routine of a well-regulated hospital.

Thirst is not altogether a matter of the amount of fluid in the tissues, hence one must not promise too much for hypodermoclysis as an immediate reliever of this aggravating manifestation. There is only one way to relieve thirst, as such, but a reasonable individual will try hard to bear this form of torture if he be assured that his tissues are really getting plenty of fluid, although none is swallowed. There is, of course, a great variety of reasons why fluid cannot be taken in the normal manner. An individual who is vomiting usually does better if his stomach is given a rest, no matter what the cause may be. There can be no argument regarding the advisability of keeping fluids away from one suffering from mechanical obstruction of the digestive apparatus. It is in many instances better to keep the gastroenteric tract at rest for a time after it has been the subject of surgical or other forms of trauma, and surely no fluid may be swallowed if the spread of a peritoneal infection is to be limited by intestinal quiet.

There are indeed many avenues for the introduction of fluid into the human body. The intravenous administration has, of course, a place in our therapeutics, and in many cases has been used with great success for drop-by-drop saline. This requires, however, a certain degree of surgical skill, and is perhaps not generally applicable. The gall-bladder has been employed with great success by McArthur, Matas, *et al.*, but is available in but a small percentage of individuals who have to have fluid. The intraperitoneal method is used largely by pediatricians, but seems not to have been generally employed in adults. Fluids have been introduced into arteries, but I believe this phase of the subject can be dismissed without any discussion. Some fluid is absorbed from the pleura, but no one would think of utilizing that membrane for the introduction of water under ordinary circumstances. It is not at all difficult to introduce a small cannula into the intestine during an abdominal operation, still, the intestine is not always available, and the risk of sepsis would probably offset to a certain extent any value attached to the method.

Proctoclysis is widely used, and was, up to about two years ago, supposed by me to be a procedure of considerable value, usefulness, although *disturbing to my patients*. I gave it up because painstaking nurses finally convinced me that the fluid was not usually retained, and I would take the liberty of suggesting that those who think it of value administer it a few times *in person* and watch the results before continuing to use it as a routine procedure.

Hypodermoclysis has given me greater satisfaction than has any other method of introducing fluids vicariously, still, it is not ideal, nor is any other procedure but drinking. When one orders hypodermoclysis, he does so with the full knowledge that infection or tissue devitalization is possible, and that the region affected is quite likely to remain very tender for two or three days, but of one thing he can now be reasonably certain, *viz.*, that a continuous inflow of  $\frac{1}{16}$  per cent. novocaine can be maintained with most patients, as long as indicated, without causing discomfort or toxic symptoms.

## REGIONAL ANÆSTHESIA\*

A SHORT REVIEW OF THE GENERAL PRINCIPLES

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SPECIAL LECTURER ON REGIONAL ANÆSTHESIA

INDUCING local or regional anæsthesia for minor operations has reached a high degree of perfection and has proved successful even when dealing with the majority of unprepared patients, that is, patients who have had no preliminary psychic treatment. These patients generally volunteer their consent to the method on the advice of the surgeon in whom they have placed all their confidence. Very few resist after they have been made to understand its meaning and the real benefit they will derive from it. But, whenever a major operation is contemplated, the question arises whether or not the patient is likely to be a good subject for local or regional anæsthesia. Patients who are able to go through the various steps of a major operation without psychic distress usually come from localities where the method is in common use; they have been educated to the method either by friends or relatives, and a great many of them go to the surgeons who are known to use local and regional anæsthesia as a routine procedure. In countries where the majority of the surgical work is done under general anæsthesia, however, every patient needs preliminary psychic treatment and education in the hospital.

Doctor Crile's work on the local method of anæsthesia has led him to conclude that by "blocking nerve conduction local anæsthetics protect the brain from the effects of local operative injury, but they do not protect the brain against destructive psychic strain. Inhalation anæsthetics exclude the psychic stimulation of the brain cells, but do not exclude the operative stimulation."<sup>1</sup> Conditions in human beings were considered to be similar to those demonstrated in animals by these laboratory findings, and, with a view to reducing operative shock to its minimum, Crile established what he rightly calls "anoci-association." The details of the technic of anoci-association are very delicate and elaborate and require special training of the patient as well as of every one on the hospital staff, including the surgeon who needs special education in the application of local and regional anæsthesia in individual cases and special training in the operative procedures.

Some patients go to the surgeon in a state of such lowered resistance that it is often a question whether or not it would be justifiable to incur the risks of a general anæsthesia. They are frequently auto-intoxicated to such an extent that the normal metabolism and the oxygenation of the

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blood are greatly altered, thereby interfering with the essential requisites of any general anæsthesia. In such cases, the advantages of regional anæsthesia are obvious, since its main effects are limited to a relatively small region of the body, leaving intact the central nervous system, on the integrity of which depends the continuance of all the vital functions.

The degree of pain is not proportional to the intensity of the trauma. Individual differences are well marked and depend on many factors, among which the emotional element plays the chief part. Nervous excitement, especially that due to apprehension, may be so great in some patients as to interfere even with the necessary manipulations in the local and regional procedures, and make it a difficult task to carry out the steps of even a simple technic. Some patients of phlegmatic temperament have confidence in the operator and are satisfied with the promise that there will be no pain, but many others become restless and uneasy and find thirty minutes spent on the operating table a severe trial. Although they actually experience no pain, their consciousness that the operation is being performed is the principal drawback of the method. To such patients a slight touch is often interpreted as pain; a few whiffs of ether generally suffice to calm them and allow the operation to proceed without disturbance. Very few of them require ether in quantities that deprive them of the benefit of their local anæsthesia. A third category of patients accept or even ask to be anæsthetized locally, but as soon as they reach the operating room faint or ask to be etherized. It is therefore advisable, as a general rule, to blunt the consciousness of the patients and for this purpose scopolamine and morphine have proved to be most effective.

A solution containing scopolamine 0.0002 gm. and morphine 1 cg. is injected one hour before the anæsthesia is induced. The injection of a smaller dose or of the same dose at a later stage seems to act on some patients as an excitant rather than as a sedative. After the injection, the patient should be kept quiet in a darkened room; he should be wheeled into the operating room on a stretcher and handled as gently as possible and every unnecessary stimulation avoided. This injection is not meant to produce a twilight sleep during which rough handling might be carried out without disadvantage, but to abolish fear, anxiety or uneasiness and determine a more placid state of mind; and the most characteristic features of its results are the pleasant mood and obedient behavior of these patients in marked contrast to many others not so treated. Morphine may be replaced by pantopon, sedol or siderol, which are opium alkaloids. Good results may be obtained with a hypodermic injection of:

Morphine hydrochlor. ....	0.01 gm.
Scopolamine .....	0.0002 gm.
Sparteine sulphate .....	0.05 gm.
Strychnine sulphate .....	0.002 gm.

Scopolamine and morphine congest the brain and sparteine stimulates the heart. Strychnine acts on the cord and checks the action of any

impurities contained in the novocaine solution; it also helps to keep the respiratory centres at work and support the blood-pressure. There are no disagreeable symptoms with scopolamine, provided our average dose is not overlooked. Nausea and vomiting have been observed in some cases even with morphine alone and especially when it is injected too late. I do not think that this can be attributed to scopolamine, but I am prone to believe that it is peculiar to certain kinds of neurotics or is due to a reflex in the course of abdominal operations or pelvic work with the patient in the Trendelenburg position.

Novocaine solutions are adopted almost universally for local and regional anæsthesia. Cocaine was used by Reclus and Schleich in the early days of the method, but these pioneers rejected it as soon as novocaine was discovered. Novocaine is about ten times less toxic than cocaine, but the analgesia is delayed and of relatively short duration, so that some adrenalin must be added to the solution in order to accelerate its effects and render it almost as active as cocaine. Other substances may be added for the same purpose: calcium chloride, sodium bicarbonate, sodium sulphate, and gelatine have been tried with varying and indefinite results. Twenty to thirty drops of a 1:1000 solution of adrenalin is the usual dose in 100 c.c. of novocaine solution, irrespective of the strength of the solution; this dose should be diminished by half for children and old persons. Fresh solutions of adrenalin are the most active, but I am not prepared to say that they are the safest, inasmuch as the toxic symptoms reported by a few observers might be accounted for by the presence of impurities in the novocaine solution.

For local and regional anæsthesia it is sometimes necessary to inject large quantities of fluid, and this is of appreciable disadvantage in regions where the scarcity of loose tissues does not permit of a fair infiltration without marked distortion of the anatomic features of the operative area, aside from the sharp pain from a sudden and marked œdema. With a view to reducing these quantities of fluid, a small proportion of cocaine was added to the novocaine, in order to obtain a reinforcement of the latter. A solution containing 10 cg. of cocaine and 90 cg. of novocaine per 100 c.c. in doses of from 100 c.c. to 125 c.c. produced symptoms of intoxication (nervous excitement, cardiac distress, labored breathing, pallor of the face, and collapse; in some cases the effects were limited to talkativeness, shouting and singing). The reduction in the amount of liquid injected was negligible, but the duration of anæsthesia was increased. A solution containing only cocaine (0.5 per cent.) gave rise to even graver symptoms when about 40 c.c. had been injected. On the other hand, 100 c.c. to 125 c.c. of a 1:100 pure novocaine and adrenalin solution (25 drops per 100 c.c.) injected systematically in a series of more than 1000 cases did not produce any untoward effects, and the duration of the anæsthesia proved sufficient even for the longest operations. I have thus been led to believe that pure novocaine adrenalin solutions are the safest;

novocaine-cocaine mixtures are dangerous; and *pure cocaine solutions should never be used in regional anæsthesia.*

The strength of the solutions varies with the technic; 0.5 per cent. is used for subcutaneous infiltration; 1 per cent. for paravertebral, caudal and muscular injections and for the anæsthesia of the head, hand, and foot; 2 per cent. for caudal injections and for blocking the brachial plexus and the great nerve trunks; and 5 per cent. in the surgery of the eye.

Needles should be long, thin, and flexible; steel nickel-plated needles are the best, and they should exactly fit the syringe. Straight needles are satisfactory, provided their attachment on the syringe is excentric, so as to allow injections to be made parallel with the skin surface. Special syringes with suitable wings for the fingers offer a better grasp than the ordinary Luer. Glass syringes should be preferred to all metal ones, because it is highly desirable to control their contents at any stage of the procedure; the plunger should be loose but air tight.

Gentleness is the first requisite of the anæsthetist. Before anæsthesia is begun, the patient should be warned that he will feel a few light pin-pricks, but that all the subsequent operative manœuvres will be painless, although the sense of touch and pull will not be abolished. If he is unwilling to be conscious of what is going on, his ears should be plugged with cotton and his eyes bandaged. The anæsthetist should handle his needle and his patient with equal dexterity. His knowledge in anatomy should be as perfect as possible, especially so far as nerve distribution is concerned. He should know how best to gain access to the nerves he wishes to anæsthetize. Needles and syringes should be tested before use, so as to make sure that they are in good working order. Anæsthetic wheals should be made wherever the skin is to be punctured. Bones serving as deep landmarks should be approached lightly with the needle, since the periosteum is very sensitive; rough contact with the framework usually bends the point of the needle into a hook which tears through the tissues as it is withdrawn. Infiltration should be slow, steady, and continuous as the needle advances in the subcutaneous tissue, as well as when it is withdrawn. The needle should never be previously attached to the syringe when it has to be introduced in the vicinity of large blood-vessels, and time should always be allowed before the syringe is fitted on, so as to ascertain that the point of the needle is not lying in the lumen of a blood-vessel. The presence of blood prompts the slight withdrawal of the needle until the flow ceases, and, if the needle has to be introduced more deeply, its direction should be changed. A small hæmatoma caused by the accidental wounding of any blood-vessel by the fine needle is of no importance; it might, however, interfere with the results of anæsthesia. It is advisable to aspirate before injecting. The injection should be made slowly and the aspiration test renewed now and again. The injection of a few drops of solution into the pleural cavity is immediately followed by coughing; injection into the lung is usually announced by

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the patient as a bad taste. These small accidents are the result of poor technic; they are not dangerous, but they should be avoided. Paraneural or extraneural infiltration should be preferred to intraneural injection.

The surgeon should wait at least ten minutes to obtain the full anæsthetic effects. He should inspire his patient with confidence, make sure that the latter is lying at ease on a soft cushion, with as little restraint as possible, so that he may undergo the operation with the minimum of discomfort. The patient should not be told when the operation begins; it should be the duty of a trained nurse to talk to him from beginning to end, diverting his attention to pleasant topics. Sharp instruments should be used; cutting with the scalpel should be preferred to snipping with the scissors. On no account should the tissues be torn through or bruised by rough handling. Retractors should be introduced lightly and opened out gradually. Pulls on the viscera should be light and gradual. The organs should not be unnecessarily drawn out of the abdominal wound. Blood-vessels and pedicles should be clamped and ligated with as little traction as possible. Incisions should always be made longer than in operations with general anæsthesia, thus exposing more freely the deep layers and avoiding unnecessary trauma to the neighboring tissues. The fact should never be lost sight of that the anæsthesia induced does not extend, as a rule, very far beyond the operative field; between the anæsthetized area and the neighboring regions a zone of hyperæsthesia seems to exist, on which distant pulls may be painful.

Nerve blocking may be accomplished by four methods, the judicious combination of which meets the purposes of any operation.

1. Blocking the nerve terminals in the immediate vicinity or around the operative area.

2. Blocking the nerves at any point from the spine or skull foramina to the area they supply. The nerves are more accessible in the superficial layers in the immediate vicinity of fixed landmarks. When the anæsthetic solution is injected close to the spine, the method constitutes paravertebral conduction anæsthesia, the Laeven method.

3. Blocking the roots within the spine, but outside the dura mater; called the extradural, epidural or sacral method.

4. Blocking the roots within the dura; known as the intradural or spinal analgesia.

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## SOME SURGICAL ASPECTS OF ASPHYXIA\*

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THE general subject which I have the honor to discuss, "Analysis of the Blood and Biological Reactions in Surgical Affections," has impressed me as so broad that it has seemed more feasible to choose for presentation only one fundamental biological disturbance. In selecting the sub-title of "Some Surgical Aspects of Asphyxia" it has appeared to me that much might be said of many new facts which are daily being discovered in the laboratories of the fundamental sciences, many of which are of direct practical applicability, and others of which are undoubtedly of potential importance to surgery. The achievements of modern surgery to-day have been made possible chiefly because the surgeon, Lister, recognized the applicability to surgery of the work of the chemist, Pasteur. Future surgical progress will necessarily depend more and more upon the application to the patient of fundamental biological discoveries. The great advances in medicine and surgery will come from those who are so trained in the fundamental sciences that they can recognize the practical application of developments in those sciences to the clinic.

That the disturbance of so fundamental a property of living matter as respiration will lead to serious consequences needs no argument to defend. It will rather be my purpose to call attention to certain ways by which respiration may be disturbed and to some of the consequences which follow any interference with the normal exchange of oxygen and carbon dioxide in the tissues. As a corollary to this point of view, also, some effects of disturbed normal oxidations will be considered as analogous to an asphyxial process, even although they are not associated with a general deficient oxidation in the body. The amount of available knowledge on this question is now so vast that any discussion of this sort will necessarily seem incomplete. I have tried to select chiefly those facts which apparently have a more or less direct applicability to surgery. By the word "respiration" as used in this article I mean not only the act of taking air into the lungs, but cellular respiration as well, the normal interchange of oxygen and carbon dioxide which goes on within all living cells.

### PART I

Disturbances of tissue respiration in the human body may occur in any of the following ways:

1. Interference with the intake of oxygen.
2. Interference with the normal power of the blood to carry oxygen, or to remove carbon dioxide.

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3. Interference with the circulation of the blood.
4. Interference with the power of the tissues to utilize oxygen.

All of these factors are of interest to the surgeon because he meets with them in his daily experience. In fact, in carrying out a surgical procedure on a single patient he may meet with some phase of all of these factors. A further analysis of them, therefore, will not be inappropriate.

*Interference with the Normal Intake of Oxygen.*—Interference with the normal intake of oxygen will occur not only with obstruction of the upper air-passages but also in conditions in which there is a reduction of the normal alveolar space of the lungs, and in the breathing of rarefied air. Limitations of time will prevent a thorough consideration of all of these conditions, but certain facts stand out prominently in regard to the reduction of the normal alveolar space of the lungs which are of such peculiar interest and importance to the surgeon that they seem worthy of an extensive discussion. The common causes of this reduction in available breathing area are to be found either in conditions within the lungs, such as oedema and inflammatory exudates, or outside of the lungs, such as abnormal pressures which limit their normal expansion. It is particularly this latter group of conditions which I desire to consider.

It is not without interest that the first "rapport" in the proceedings of this Congress in 1911 was on "Pneumothorax" and that it dealt very largely with a discussion of cumbersome apparatus which had been devised for performing intrathoracic operations with the elimination of the much-dreaded danger of pneumothorax. The war, however, has demonstrated that surprisingly large openings in the thoracic wall are not necessarily followed by death from asphyxia; and the brilliant work of Duval,<sup>1</sup> Grégoire,<sup>2</sup> Gask and Wilkinson<sup>3</sup> and others has shown us that bold operative attack on the lung may be made without recourse to any special apparatus to combat the pneumothorax, and with a degree of success which would have seemed incredible at the time of the last meeting of this Congress. Despite, however, the remarkable operative results which have been obtained, often with an apparently complete neglect of the dangers of an open pneumothorax, nevertheless its inherent danger as a cause of fatal asphyxia in some cases remains, and will continue to remain if steps are not taken to avoid it. It will not be out of place, therefore, to consider the mechanism of action of pneumothorax in some detail; and I believe it has been possible to show that, as a result of recent work, the previous ideas of it are incorrect.

The former, usual conceptions of pneumothorax are based on the assumption that even in the normal chest the mediastinal structures constitute a more or less rigid partition between the two pleural cavities. The general opinion has existed, therefore, that if an open pneumothorax is created on one side, "collapse" of that lung will occur and respiration will be maintained only with the other lung. Evidence of the extent to which this belief is prevalent is seen in the common expressions of "collapsed lung," "sound lung," etc. In the "rapport" on "Pneumo-

thorax" to which reference has already been made Garré stated that, "In open pneumothorax the collapsed lung is functionally completely shut out. With every inspiration the pressure in the two pleural spaces will be different: in the pneumothorax atmospheric pressure, on the sound side a negative pressure ( $-7$  mm. Hg)." The excellent treatises of Emerson,<sup>6</sup> Sauerbruch,<sup>8</sup> and L. Mayer<sup>7</sup> also reflect this same idea of the "collapse" of the lung on the opened side.

As a matter of fact, however, it is possible to obtain evidence experimentally which seems to prove that these conceptions are incorrect. On the contrary, the mediastinum is so mobile in the normal chest that it offers practically no resistance to even slight pressure changes on either side of it. The experiments about to be described were performed in 1918 by Captain R. D. Bell and myself<sup>8</sup> while members of the Empyema Commission of the United States Army; the details may be found in the original article.

If air is injected into one pleural cavity of a normal human thorax until a pressure of 10 cm. of water is obtained, the pressure in the opposite pleural cavity will register an amount which varies in different individuals from 9 to 9.5 cm. of water. The resistance offered by the mediastinum, therefore, to even so slight a pressure as 10 cm. of water amounts to only 0.5 cm. to 1 cm. of water (0.4 mm. to 0.8 mm. of mercury), which is negligible. These results were obtained on five human cadavers immediately after death, while the bodies were still warm. They are shown graphically in Figs. 1 and 2. Normal dogs, also, which have been killed with ether show identical results immediately after death (Fig. 3). It seems reasonable, therefore, to assume that phenomena observed experimentally on the living dog may be directly applied to the living human.

If an open pneumothorax is created on one side in the normal living dog a characteristic response occurs which is manifested not only by a change of intrapleural pressure on the opened side but also by a change of the same kind, and of practically the same degree, on the unopened side. Briefly, the phenomena which occur are as follows: Immediately after making the opening there is a simultaneous change of pressure in the two pleural cavities from an entirely negative (less than atmospheric) phase to one which oscillates between positive (more than atmospheric) and negative. The size of the opening, as will be shown later, materially influences the extent of the change of pressure. The respirations are sometimes slowed and increased in amplitude, but at other times they are accelerated. As the intrapleural pressure increases, the intratracheal pressure diminishes, as would be expected, since the latter is a rough index of the amount of air passing down the trachea. Immediately upon closure of the opening there is a simultaneous response in both pleural cavities, with a more complete restoration of negative pressure, diminution of the amplitude of the respiratory movements and oscillations again of negative and positive intratracheal pressure on inspiration and expiration (Fig. 4).

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*A priori* it would seem to follow from all this that in the normal chest an open pneumothorax on one side would produce practically an equal amount of compression of both lungs instead of resulting in a collapse of one lung with maintenance of respiration by the other. Again, direct experiment seems to confirm the truth of this conclusion. For determinations of the relative densities of the two lungs after altering the pressure in one pleural cavity show that, within the range of experimental error, the densities are the same and therefore that both lungs are practically equally compressed. The following table shows the relative densities of the lungs of five dogs, in three of which one pleural cavity had been inflated with air to a pressure equal to that of 10 cm. of water:

	Density of lungs	
	Left	Right
No. 1. Right pleural cavity inflated with air to a pressure equal to that of 10 cm. of water .....	0.74	0.74
No. 2. Left pleural cavity inflated .....	0.73	0.69
No. 3. Left pleural cavity inflated .....	0.70	0.72
No. 4. Control, not inflated .....	0.52	0.48
No. 5. Control, not inflated .....	0.43	0.51

The extreme mobility of the human mediastinum in the absence of adhesions has been shown in X-ray studies on pneumothorax by Stivelman and Rosenblatt.<sup>9</sup> Their work tends to confirm the truth of the general idea here being developed of the practical equilibrium of pressure throughout the normal thorax. J. B. Murphy,<sup>10</sup> recognizing the dangerous tendency of the mediastinum to "flutter" in an open pneumothorax, recommended traction on the lung in an attempt to immobilize the mediastinum.

Additional evidence in support of the equality of pressure in the two pleural cavities is obtained when one pleural space of a living dog is injected with a solution of agar. After the agar has solidified by cooling, a cast of the pleural cavity is obtained which allows a direct vision of the relationships which the various intrathoracic structures had to each other during life. Fig. 5 is a photograph of a dog which, while still alive but under ether anæsthesia, received into the right pleural cavity an injection of a solution of agar. The injection was made slowly and was continued until the animal stopped breathing. A long median laparotomy incision was made in order to observe the bulging downwards of the diaphragm. It will be seen in the photograph that, although the injection was made into the right pleural cavity, the left diaphragm bulged downwards and the liver was pushed down on the left side as well as on the right. After death the animal was placed in a refrigerator to allow the agar to solidify by cooling, and later the sternum and a large portion of the anterior thoracic wall were removed. In Fig. 6 it will be observed that both pleural cavities (A and C) are about equal in size. At B is shown the mass of solidified agar which not only occupies most of the right pleural cavity but has also pushed over the mediastinal structures into the left

side of the thorax. The heart (D) almost touched the left lateral wall of the thorax. The right lung was found encased in the agar and lying against the posterior wall instead of being contracted into a small mass about the hilum, as is generally supposed to happen when the lung is compressed. The left lung was also crowded against the posterior wall by the bulging over of the heart and other mediastinal contents. This experiment seems to afford visual confirmation of the idea of the approximate equality of pressures in the two pleural cavities in the dog; and since by previous experiment it had been determined that a freshly killed dog reacts in a manner identical to the human body immediately after death, it seems fair to assume that the conditions found in the dog after the injection of agar are the same as those which would occur in the living normal human.

The older conceptions of the immediate establishment of atmospheric pressure within a pleural space as soon as an open pneumothorax is created fail to take into consideration the fact that the thorax, instead of being a rigid box, has movable walls which, by varying the size of the contained space, also vary the pressure within it. If the older conceptions were correct, then a small opening into the chest would have the same consequences as a large one because in each case "collapse" of the corresponding lung would occur. It would follow from this also that in a normal chest a unilateral open pneumothorax ought never to be fatal regardless of how large the opening might be, since the worst possible consequence would be the "collapse" of one lung. Similarly, also, with the same line of reasoning, a bilateral open pneumothorax should always be promptly fatal. Experiences, however, both experimental and in the war, which controvert these two conclusions, have been many. It is also easy experimentally to demonstrate that there is a definitely quantitative relationship which exists, in any individual with a normal thorax, between the size of the opening in an open pneumothorax and the danger of death, because the really important factor is the amount of air which enters the chest from the outside with each inspiration.

A mathematical expression has been devised by which it is possible to approximate in a given case the maximum opening in the chest wall which is compatible with life. This expression is as follows:

$$X = \frac{V - \frac{R_1}{R_2} T}{\frac{R_1}{R_2} T} aC$$

in which V is the vital capacity,  
 $R_1$  is the rate of respiration before the opening is made,  
 $R_2$  is the rate of respiration after the opening is made,  
 T is the tidal air (approximately 500 c.c.),  
 a is a factor less than 1 (assumed to be about 0.8),  
 C is the area of the glottis (about 2.25 sq. cm.).

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By substituting numerical values the determination of  $X$  becomes a problem of simple arithmetic. The average vital capacity  $V$  and the tidal air  $T$  are given by Howell<sup>11</sup> as 3700 c.c. and 500 c.c., respectively. The normal rate of respiration  $R_1$  during complete rest is about 15 per minute and the maximum rate  $R_2$  for the greatest possible depth of respiration is about 60 per minute.

$$\frac{R_1}{R_2} T \text{ then equals } 125 \text{ and}$$

$$X = \frac{3700 - 125}{125} aC = 28.6 aC$$

$$X = 28.6 (0.8 \times 2.25) = 51.5 \text{ sq. cm.}$$

In other words, in an individual with an average "vital capacity" (3700 c.c.) an opening of about 51.5 sq. cm. (8.1 sq. inches) is the largest for which compensation can be made if the mediastinum has a normal mobility. It is obvious, however, that when the factor  $V$  ("vital capacity") is increased the value of  $X$  will also increase. Consequently those individuals whose "vital capacities" are greater than 3700 c.c. will be able to withstand openings of greater areas than 51.5 sq. cm. In this connection it is noteworthy that Peabody and Wentworth have shown that the average vital capacity for men is considerably higher than that of the general average of both men and women. The average value based on their observations on men is 4633 c.c. If we substitute this value for  $V$  in our equation we find a value for  $X$  of 64.8 sq. cm. (10 sq. inches). The maximum opening, therefore, for which the average man can compensate is about 64.8 sq. cm. In the exceptionally large man of athletic build, as, for example, in the case of the man mentioned by Peabody and Wentworth,<sup>12</sup> who had a "vital capacity" of 7180 c.c., a relatively enormous opening in the chest wall can be compensated for. In such a case, for instance, the value of  $X$  in our equation would be 101.3 sq. cm., or 15.6 sq. inches. Practically, the opening must be somewhat smaller, since the extra work performed by the muscles of respiration to establish compensation increases the amount of air required. The presence of toxæmia, infection or any other cause which increases the level of metabolism will decrease the safety limits of the maximum size of the opening, as will also any condition reducing the available breathing space of the lung. The use of general anæsthesia will probably also act in the same way. It should be borne in mind that the value of  $X$  represents the approximate maximum opening compatible with life only so long as the respiratory muscles can maintain a maximum respiratory movement, and in addition, that it is only an approximation because of the variability in different individuals of some of the other factors, as, for example,  $C$ . It is striking, however, that, owing to the negligible resistance offered by the mediastinum, it makes very little difference whether there is a unilateral or a bilateral open pneumothorax, provided that the combined areas of the openings in the bilateral case do not exceed the area of the unilateral

opening. This fact clearly controverts the former conception of the necessary "collapse" of a lung after the creation of a pneumothorax. In fact, if in a living dog an opening into the chest be made in a suitable place for inspection, as, for example, in about the fifth interspace in the mid-axillary line, the expansion and contraction of the lung can be observed to occur with each act of respiration.

The reasons for this quantitative relationship are to be found in the facts that: (1) it is possible to maintain life as long as the lungs can inspire the "tidal air," which normally is from 300 c.c. to 500 c.c.; (2) a considerable encroachment on the volume of the two lungs can be made before a stage is reached at which it is no longer possible for the lungs to obtain the "tidal air," and (3) in the compensatory reaction, by an increase in the amplitude of the respiratory movements the thorax is enlarged so that actually more air may enter through the pneumothorax opening without encroaching on the "tidal air" to the same extent than would be the case if the thorax were not enlarged.

It must be particularly emphasized, however, that this consideration of the practically negligible resistance of the mediastinum, with the associated equality of pressure throughout the thorax, refers only to the normal thorax. Obviously, a thickening of the mediastinum by old inflammation and the presence of strong adhesions will change the conditions and will permit the development of a considerably greater pressure on one side than on the other.

In addition to its effects on respiration, an open pneumothorax also induces other harmful effects. These have been summarized by Sauerbruch as loss of heat, danger of infection and disturbances of the circulation. He has made the important observation that the loss of heat from an open pneumothorax may exceed that which follows an extensive laparotomy incision with eventration of the intestine. Also, owing to the changed pressure relationships, a stasis in the venous system occurs which is shown by an actual increase of pressure in the femoral vein.

In the case of a closed pneumothorax very different conditions from those in an open pneumothorax are present. In the description of the characteristic changes produced by making a free opening into the pleural cavity it was stated that the closure of the opening resulted in a sudden restoration of negative pleural pressure and a prompt relief from dyspnoea. Obviously, after making the closure, air is still retained in the pleural cavity, so that the very striking difference in the phenomena observed must be due merely to the fact that an open pneumothorax has been converted into a closed one. Although air is absorbed from the pleural cavity, it disappears only slowly; and the sudden benefit noted by the closure of the opening cannot be attributed to the immediate disappearance of the air. Apparently the explanation of the relative harmlessness of a closed, in comparison with an open, pneumothorax lies rather in the fact that the ability to compensate for interference with the aëration of

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the lungs is limited. In a closed pneumothorax, no matter how much air is contained in a pleural cavity, no additional air can enter. It is necessary, therefore, only for the animal to increase his respiratory effort sufficiently to create enough negative pressure to allow him to take in the requisite amount of air to maintain oxygenation of his blood. Under conditions of rest this amount is equivalent only to the "tidal air," which in the human is only a relatively small fraction of the "vital capacity" (from about one-seventh to one-twelfth). Accordingly, therefore, a fatal asphyxia should not occur until so large a proportion of the lung capacity has been replaced by air in the pleural cavity that his "vital capacity" equals his "tidal air," provided that the animal is at rest, that his ability to compensate by increasing his respiratory effort is good and that there is no extra abnormal demand for air such as might arise from toxæmia. When an open pneumothorax is converted into a closed one, particularly if the closure is made at the end of expiration, the amount of air enclosed in the pleural cavity is very much less than the normal difference between the "tidal air" and "vital capacity," and naturally, therefore, there is comparatively little dyspnœa. On the other hand, in the case of an open pneumothorax there is an active competition for air going on between the trachea and the pleural opening. At each inspiration air not only enters the trachea but also enters the pleural cavity, and if the diameter of the pleural opening is the same as that of the glottis, practically the same amount of air will enter the pleural cavity as will enter the lungs, and the animal will be compelled to increase his respiratory effort to get the "tidal air" into his lungs. If the opening is considerably larger than the glottis it will be still more difficult to get the required amount of air into the lungs. When it is so large that more air than the difference between the "tidal air" and the original "vital capacity" enters the pleural cavity with each inspiration, the animal will no longer be able to obtain the requisite "tidal air" and death from asphyxia will occur. This theoretical discussion is, of course, only an approximation and is not strictly accurate, since it is necessary to consider the actual amount of air entering by each opening rather than merely the difference in area, a consideration which involves also the relative lengths of the pleural opening and the trachea with the resultant friction to the passage of the air. Observations, however, both clinical and experimental, tend to confirm the truth of this explanation. Clinically, it is well known that an individual of average size may have no alarming dyspnœa from a pleural exudate amounting to 2000 c.c. or 2500 c.c. Exudates greater than this, however, frequently produce very severe dyspnœa, particularly if the respiratory muscles are weak. Experimentally we have injected into the pleural cavity of a dog of 8 kilos, through a small needle, as much as 1800 c.c. of air over an interval of twenty minutes without producing any marked asphyxia. Beyond that point, however, additional injections of only 50

c.c. at a time each had a very noticeable effect in increasing the dyspnoea, and the animal died after about 2100 c.c. of air had been injected.

The applications of these newer conceptions of the physiology of pneumothorax are very extensive, but they have a particular bearing upon the questions of both the treatment of empyema and the handling of wounds of the thorax.

During the winter of 1917-1918 the military camps in the United States were ravaged by a very severe epidemic of respiratory infections associated with a hæmolytic streptococcus. A very extensive bronchopneumonia and a high incidence of empyema were conspicuous features of this epidemic. Clinically, during the acute stage of the illness, an extreme grade of cyanosis, dyspnoea and air-hunger were common; and at autopsy, as was well shown by MacCallum,<sup>13</sup> a ready explanation was found in the fact that many of the bronchioles were completely occluded both by contained exudate and by œdema and induration of their walls, so that often there existed an actual impediment to the passage of air into alveoli which were not themselves already filled with exudate. Early in the course of the disease there occurred a pleuritis accompanied by a massive fluid exudate which contained myriads of hæmolytic streptococci. In the early stages this exudate was only slightly purulent but was rather markedly hemorrhagic. Later it became more and more purulent, so that usually at the expiration of about ten days or two weeks it was frankly purulent.

In general the method of treatment that was at first employed was the conventional one of the establishment of open drainage, either by a simple thoracotomy or a rib resection, as soon as the diagnosis was made of the presence of fluid containing streptococci. Alarming reports of the high mortality of these cases led to the appointment, by the Surgeon General, of an Empyema Commission<sup>14</sup> for the purpose of making a thorough investigation of the question. My good fortune in being made a member of this Commission afforded me the opportunity of observing an unusually large number of cases of empyema. The average mortality based on replies from all the camps in February, 1918, was 30.2 per cent., but in some of the camps it reached the appalling figure of from 70 to 95 per cent. Realizing that any further embarrassment to respiration might be fatal in those who were already having difficulty to obtain enough air to support life, the Commission instituted at Camp Lee, Virginia, a change in the plan of treatment. Instead of inducing early drainage, aspirations with a Potain aspirator were performed as often as necessary, with the idea of delaying operation until the active pneumonia had subsided. Following this procedure there was an immediate drop in mortality to 4.3 per cent., and in 13 per cent. of our cases aspiration alone proved sufficient, so that it never became necessary to establish drainage. At other camps, also, where independently the principle of the avoidance of an open pneumothorax in the early stage of the disease was instituted, a marked fall in the mortality occurred. Stone<sup>15</sup> has shown the drop in

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mortality which occurred at Fort Riley, Kansas, after substituting aspiration for operation during the early acute stage. His cases are divided into three series, and the following quotation from his article will reveal the striking difference in mortality:

"1. First series: Early operation (October 20, 1917, to January 21, 1918), 85 cases. Mortality, 61.2 per cent.

"2. Second series: Early aspirations and late operation (January 12, 1918, to August 10, 1918), 96 cases. Mortality, 15.6 per cent.

"3. Third series: Early aspirations and late operation (October 18, 1918, to February 14, 1919), 94 cases. Mortality, 9.5 per cent."

It is possible that one factor in the remarkable reduction of mortality in these cases was a diminished virulence of the organism. On the contrary, however, as a result of the experience with the epidemic in the army, there exists now in the United States an almost unanimous feeling that the creation of an open pneumothorax during the acute pneumonic stage of an empyema should be scrupulously avoided. The experimental findings discussed above seem to afford a rational explanation of the danger inherent in the establishment of open drainage at too early a period, and they are particularly applicable to streptococcus cases. When it is recalled that in these cases the type of pneumonia is such that many of the bronchioles are occluded, it occasions no surprise that a high grade of cyanosis and dyspnoea exists. This situation in turn will lead inevitably to a marked reduction of the "vital capacity." The result of any considerable reduction of the "vital capacity" will in turn diminish the size of the opening which can be made in the chest wall without producing a fatal asphyxia, and if the "vital capacity" becomes so low that it equals the "tidal air," then it will be impossible to compensate for an opening of any size. If, however, an opening is not made until later, after the active pneumonia has subsided, then very different conditions are encountered. In the first place, the subsidence of the pneumonia has opened up the occluded bronchioles so that the patient is no longer suffering from air-hunger. His "vital capacity" is, therefore, considerably increased. Moreover, adhesions have formed so that actually the opening is not made into a free pleural cavity, but into a circumscribed abscess. The dangers of an open pneumothorax at this time have consequently been reduced to a minimum. The more favorable mortality figures in cases of pneumococcus empyema are perhaps due, in a large measure, to the fact that the condition is generally not recognized and therefore not operated upon until after the pneumonia has subsided. The older conceptions of pneumothorax will not adequately explain the harmful effects of open drainage during the early, pneumonic stage of an empyema. For, according to such conceptions, the worst that could happen would be the collapse of the lung on the affected side; and furthermore, a large opening would have slightly, if any, greater consequences than a small one.

Another application of the experimental results concerns the question

of wounds of the thorax. Reference has already been made to the experience of all army surgeons that surprisingly large gaping wounds of the thoracic wall did not necessarily result in a fatal asphyxia. This finding is easily explained, however, by the quantitative relationship between the size of the opening, the "vital capacity," and the other factors mentioned above in this connection. For it has been shown, on the basis of our calculations, that an average normal man, even without adhesions, can compensate for an opening of about 64.8 square centimetres (10 square inches) until his respiratory muscles become fatigued or unless his need of oxygen becomes abnormally great. Practically, in operative procedures on the chest, measures are always adopted by the operator to reduce the size of the opening. One which is apparently very large is often actually much smaller, because of the presence in the incision of a lung which has been delivered out, gauze sponges, instruments, and fingers of the operator or of his assistants, all of which by their plugging tend to reduce the area of the opening. Also, the delivery of the lung outside of the chest wall accomplishes to some extent the immobilization of the mediastinum. There is, therefore, apparently a perfect harmony between the conceptions of pneumothorax based on the above experimental results and the clinical observations on wounds of the thorax.

*Interference with the Power of the Blood to Carry Oxygen or to Remove Carbon Dioxide from the Tissues.*—Disturbances in the power of the blood to carry oxygen include all those conditions in which the hæmoglobin is either reduced in amount or so changed in form that the normal amount of oxyhæmoglobin is not present. Such a condition is, of course, always encountered in connection with a severe anæmia, whether acute or chronic. The marked signs of asphyxia, such as air-hunger, etc., which occur after a severe hemorrhage, are too well known to every surgeon to require comment. The asphyxial effects on the tissues of a severe chronic anæmia are likewise important, although less conspicuous clinically than those of a severe hemorrhage. These effects will be considered in more detail in Part II.

Of less importance to the surgeon are the changes which occur in the hæmoglobin itself which diminish the amount of oxyhæmoglobin. Since the tissues receive practically all of their oxygen because of the instability of the oxyhæmoglobin combination, whereby oxygen is easily split off, it becomes apparent that any other hæmoglobin combinations which would prevent, on one hand, the union with, or, on the other hand, the dissociation off of oxygen from the hæmoglobin would have practically the same effects on the individual as the loss of an equivalent amount of blood. A striking example of such a condition is found in cases of poisoning with carbon monoxide. The combination which this gas forms with hæmoglobin is a relatively stable one which prevents the union of oxygen with hæmoglobin. Poisoning with this gas therefore produces a severe general asphyxia. Other hæmoglobin combinations, also, have been described,

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such as methæmoglobin, which is found especially in pneumonia, and hydrogen sulphide hæmoglobin, etc., which in varying degrees produce asphyxial effects by interference with the normal amount of hæmoglobin available for combination with oxygen.

The question of the disturbances of the power of the blood to remove carbon dioxide from the tissues is of vital importance in connection with the phenomenon of "acidosis" which will be discussed in more detail in Part II.

*Interference with the Circulation of the Blood.*—Any condition which disturbs the normal transport of oxygen from the lungs to the tissues will also, to a more or less degree, result in asphyxial effects. Such a condition is encountered locally whenever an important vessel (either artery or vein) is occluded or destroyed. As will be seen later in Part II, a considerable difference in the results will occur, depending on the degree of the local asphyxia, its duration, and the availability of fluids to the affected tissues. Disturbances of the circulation which are accompanied by general asphyxial effects are found particularly in uncompensated heart disease, in shock, and in pneumothorax. The very excellent work on shock of Crile,<sup>16</sup> Seelig and Joseph,<sup>17</sup> Cannon,<sup>18</sup> Mann,<sup>19</sup> and of Erlanger<sup>20</sup> and his coworkers, in the United States, of Bayliss<sup>21</sup> and others in Great Britain, and of Quénu and others<sup>22</sup> in France has shown beyond a doubt that the factor of asphyxia from a disturbed circulation is of the greatest importance.

*Interference with the Power of the Tissues to Utilize Oxygen.*—Since the ultimate acts of respiration consist in the utilization of oxygen by the cells and the giving off of carbon dioxide, it becomes evident that, theoretically at least, conditions might arise which would disturb the normal power of the tissues to utilize oxygen even when available. Such disturbances, of course, if of sufficient degree, would result in a fatal asphyxia as surely as an obstruction of the trachea. For many years a large amount of evidence has been accumulating that the state of narcosis or surgical anaesthesia is associated with a definite diminution of tissue respiration. This has been shown particularly in the work of Verworn,<sup>23</sup> Mansfeld,<sup>24</sup> Mathews,<sup>25</sup> Tashiro,<sup>26</sup> and Jacques Loeb.<sup>27</sup> This reduction in tissue respiration is independent of any important disturbance with the intake of oxygen, of the oxygen-carrying power of the blood, or of the circulation of the blood. Its explanation, therefore, must lie in the inability of the cells to utilize oxygen even when it is available. The opinion is now, in fact, general that narcotic drugs as a class interfere with the power of the cells to utilize oxygen. This opinion is based chiefly on work which has been done with the common anaesthetic agents, for example, chloroform, ether, alcohol and nitrous oxide, but it doubtless is true as regards all of the narcotic drugs. The cyanides also probably owe their action chiefly to this effect. Acids interfere seriously with tissue respiration, and the effects which they induce are practically identical with those which fol-

low a severe asphyxia. The idea, originally advanced by Verworn, that narcosis is synonymous with asphyxia, has been found, however, by Loeb and Wasteneys<sup>28</sup> to be incorrect.

In diabetes mellitus there is an inability on the part of the tissues to utilize oxygen for the combustion of sugar notwithstanding the fact that there is no demonstrable deficiency of general oxidations. As a result, however, some of the conspicuous features of asphyxia are present in this disease. Likewise, in poisoning with phosphorus the characteristic lesions are practically identical with those of asphyxia, although Lusk<sup>32</sup> has shown that there is no general decrease of oxidations.

## PART II

### EFFECTS OF ASPHYXIA

The effects of interference with the normal processes of oxidation are necessarily numerous, as might be inferred from the disturbance of so fundamental a property of living matter as respiration. Some of these effects are so pronounced that visible pathological changes are induced; others are concerned more with physiological disturbances which require chemical methods for their detection.

It is, of course, a very old observation that any measure which completely shuts off the supply of oxygen to a part for a long enough time results in its necrosis. It is also well known that there is a tendency for such a part to imbibe water and to swell, if water is available. But a similar swelling or oedema is frequently observed when the oxygen supply is only partially reduced, or if completely shut off for only a short period. It therefore becomes apparent that the amount of oedema is largely dependent upon the degree to which the circulation fails to remove the products of metabolism, the oxygen deprivation and the amount of available water. It is easy to understand also that at least a transient oedema will follow the occlusion of an important artery (for example, the femoral), but that it will be less in degree than that which follows the occlusion of the corresponding vein, because in the latter case more water is made available for the swelling of the cells. In 1898 Jacques Loeb<sup>29</sup> brought oedema into relationship with a deficient supply of oxygen and the incidental formation of acid. Martin Fischer<sup>30</sup> has more recently emphasized the importance of the action of the asphyxial acids on the tissue colloids. The extensive controversy which Fischer's work has aroused, particularly in the United States, I shall avoid discussing.

Other morphological effects of disturbed oxidations are fatty "degenerative" changes and a tendency to the production of hemorrhages. For many years the presence of excessive amounts of fat in the liver in conditions of impaired oxidation was ascribed to a degenerative process by which the cell contents were actually transformed into fat. The work of Rosenfeld,<sup>31</sup> however, showed conclusively that, at least in the case of phosphorus poisoning, most of the abnormal fat is transported from the

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various fat depots in the subcutaneous tissues, the omentum, etc., and that therefore it does not represent a transformation of the cellular tissues into fat. Graham Lusk<sup>32</sup> has drawn a definite relationship of these abnormal infiltrations of fat to asphyxial conditions by showing that they occur whenever there is an inability on the part of the cell to oxidize sugar, and that consequently in reality they represent a condition of "sugar hunger" in the cell. It is not surprising, therefore, that in severe diabetes, in which there is practically a total inability on the part of the body to oxidize sugar, a marked fatty infiltration of the viscera should be found, provided that there is not a sufficient degree of emaciation as to preclude a transportation of fat from the various fat depots of the body to the liver and other viscera. An excessive fat infiltration of the liver can be readily produced in the dog by methods which induce an experimental diabetes, as, for example, by the injection of phlorizin or by removal of the pancreas. Likewise any condition associated with a general lack of oxygen, as has been shown by Araki,<sup>33</sup> Bauer,<sup>34</sup> and by Martin, Loevenhart and Bunting,<sup>35</sup> and others, will lead to an accumulation of fat in the liver and elsewhere. The evidence, therefore, seems incontrovertible that abnormal infiltration of fat is an expression of impaired oxidation.

Every severe asphyxial condition is accompanied by the production of hemorrhages. These may be localized if the asphyxia is local, as, for example, in hemorrhagic infarcts, or they may be more or less generalized if the asphyxia is general, as in obstruction of the trachea if death does not occur too suddenly. The explanation of these hemorrhages is not simple, and doubtless many factors are involved. It would seem not unlikely, however, that a fundamental and widespread change occurs as a result of which not only fibrinogen but many other proteins tend to remain in solution or to pass into solution, with the result that apart from diminished blood coagulability there is a great reduction in the firmness of the vessel walls. Some light has been thrown on this question in the very excellent series of articles by Nolf<sup>36</sup> and by Doyon<sup>36</sup> and his coworkers. These investigators have produced a considerable amount of evidence which indicates that fibrinogen is formed mainly in the liver. It follows logically from this fact, therefore, that any condition in which the function of the liver is seriously impaired may be accompanied by a tendency to the production of hemorrhages. Since the liver is one of the organs in which oxidations are most active, it is not surprising that asphyxial conditions affect it particularly and that hemorrhages are practically a constant accompaniment of a general asphyxia.

We may recognize, therefore, a definite syndrome of gross pathological changes which are induced by either a deprivation of oxygen or by impaired oxidations, although it is probable that a failure to remove the waste products of metabolism is often an important auxiliary factor in its production, especially in conditions of disturbed circulation. This syndrome consists of œdema, fat infiltration, a hemorrhagic tendency,

and necrosis. All tissues do not show these changes to the same degree even when subjected to approximately the same amount of oxygen deprivation or of disturbance of circulation. Fat infiltration, for example, is more conspicuous in the liver than in any other organ. Furthermore, although this syndrome is induced by asphyxial conditions, it is not certain that the converse is true and that it can always be considered that asphyxial conditions are present when this syndrome occurs; for, as is well known, it may be found in many severe infections and in intoxications of many kinds both with known and unknown agents. The similarity of pathological effects, however, as well as other changes which are not accompanied by visible lesions suggests that in all such cases there is a disturbance of normal cellular respiration. The group of conditions referred to comprises not only the infections with the common bacteria, but also those diseases known as acute yellow atrophy of the liver, eclampsia, etc.

Another effect of oxygen deprivation or of disturbed oxidations is the phenomenon of so-called acidosis. Originally used with reference to the abnormal accumulation and excretion of certain organic acids in diabetes, the term has more recently been given a much broader application, so that it now is used in reference to a large variety of conditions. If the normal oxidation of sugar and of fat is disturbed various organic acids and acetone may appear in the blood and urine because of a failure to oxidize them completely to  $\text{CO}_2$ . These acids, such as  $\beta$ -oxybutyric, aceto-acetic, etc., together with the acetone, represent stages in the incomplete oxidation of fat and perhaps of certain amino-acids. They may appear, therefore, not only in conditions of a general deprivation of oxygen, but also where there is a selective impairment of sugar oxidation, as in diabetes. Simultaneously also with the appearance of these substances in the urine abnormal amounts of ammonia are found, a fact which is interpreted as an expression of a mechanism to neutralize the abnormal acids. The more recent uses of the term acidosis, however, are in reference to any disturbance of the normal reserve alkalinity of the blood, whereby it becomes less able to "take up" acid than is normal blood.

As has been shown by L. J. Henderson<sup>27</sup> the reaction of the blood under normal conditions is perhaps the most constant phenomenon of any occurring in the body. The constancy of this reaction is maintained chiefly in four ways: (1) the excretion of  $\text{CO}_2$  by the lungs, (2) the excretion of acid by the urine, (3) the neutralization of acids by ammonia formed chiefly in the metabolism of proteids, and (4) the combination of acids with proteids. The common conception is that the  $\text{CO}_2$  combines with the carbonates of the blood to form bicarbonates and is carried to the lungs where it is exhaled. The normal excretory power of the kidneys is also very essential; for it is by this route that the body eliminates much acid. It is apparent, therefore, that the clinical expressions of acidosis are often intimately associated with impaired kidney function.

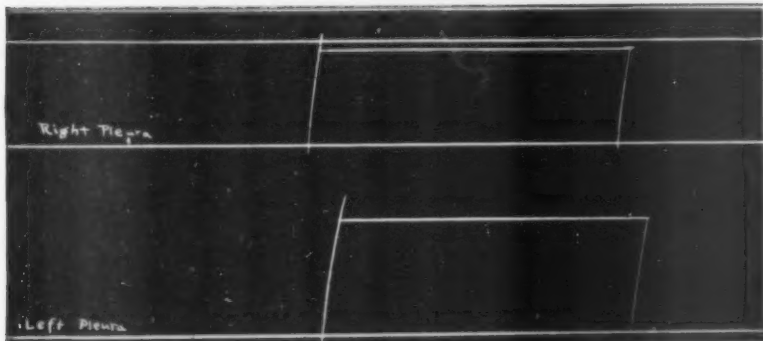


FIG. 1.—Tracing showing that when the left pleural cavity of a fresh adult human cadaver is inflated with air at a pressure of 10 cm. of water the right pleural cavity registers a pressure of 9 cm. The top line is a record of a pressure of 10 cm. made with the tambour attached to the right pleural cavity. Calibration showed that the actual pressure was 9 cm. of water.

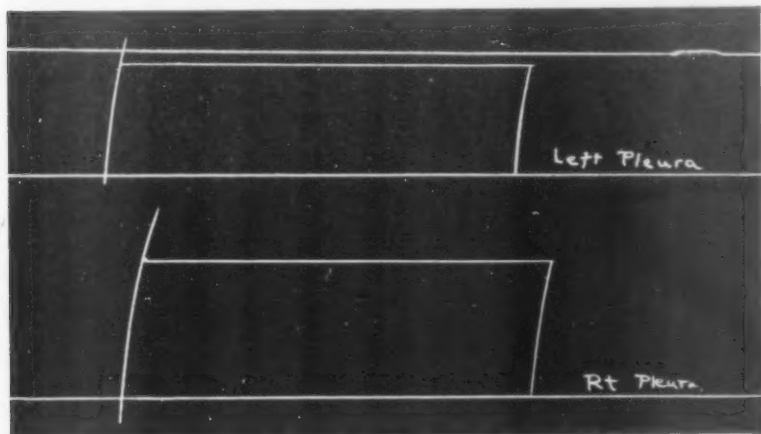


FIG. 2.—A similar tracing with the right pleural cavity inflated. Calibration showed that in this case also there was a difference in pressure of only 1 cm. of water (about 0.8 mm. of mercury).

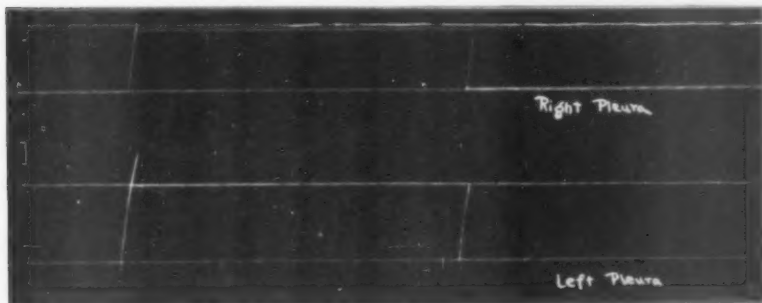


FIG. 3.—Tracing made in the same way with a recently killed dog which shows that the dog is strictly comparable with the human, since here also the difference in pressure between the two pleural cavities amounted to only 1 cm. of water.

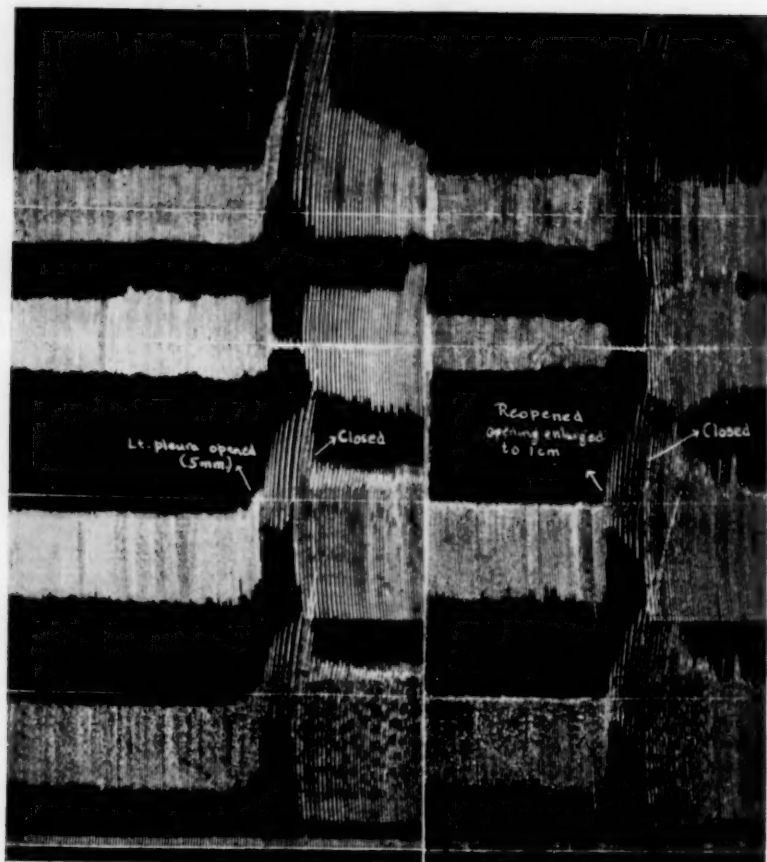


FIG. 4.—A tracing made on the living dog under ether anaesthesia to show the nature of the reaction to an open pneumothorax with a moderate opening, as indicated in the changes in the respiratory movements, in the tracheal pressure and in the pressures in both pleural cavities. The upper tracing represents the respiratory movements, the next the tracheal pressure, the third the left pleural pressure and the fourth one the right pleural pressure. The lowest line indicates the time in seconds. The base lines were drawn at atmospheric pressure. The break in the chart represents an interval of six minutes. Immediately after making the opening there is a simultaneous change of pressure in the pleural cavities from an entirely negative phase to one which is mostly positive. The respirations are slowed but are increased in amplitude. If the experiment is performed with local anaesthesia, however, the respirations are accelerated as well as being increased in amplitude, after making the opening. Because the intrapleural pressure is largely positive, practically no air enters the trachea and the intratracheal pressure tends to be at equilibrium with atmospheric pressure. Immediately upon closure of the opening there is a simultaneous response in both pleural cavities, with restoration of negative pressure to a large extent, diminution of the amplitude of the respiratory movements and oscillations again of positive and negative intratracheal pressure, with inspiration and expiration. After an interval of six minutes, during which time probably most of the air in the pleural cavities has been absorbed, the intrapleural pressure has again become entirely negative.



FIG. 5.—Photograph of a dog which had been injected into right pleural cavity with a solution of agar while alive but under ether anaesthesia. The agar solution was run in slowly until the animal died. The abdomen was opened, before beginning the experiment, by a median laparotomy incision to show the bulging downwards of the diaphragm with the associated pushing downwards of the liver. It will be noted that, although the agar solution was introduced into the right pleural cavity, the left diaphragm bulges downwards and the liver is pushed down on the left side as well as on the right.

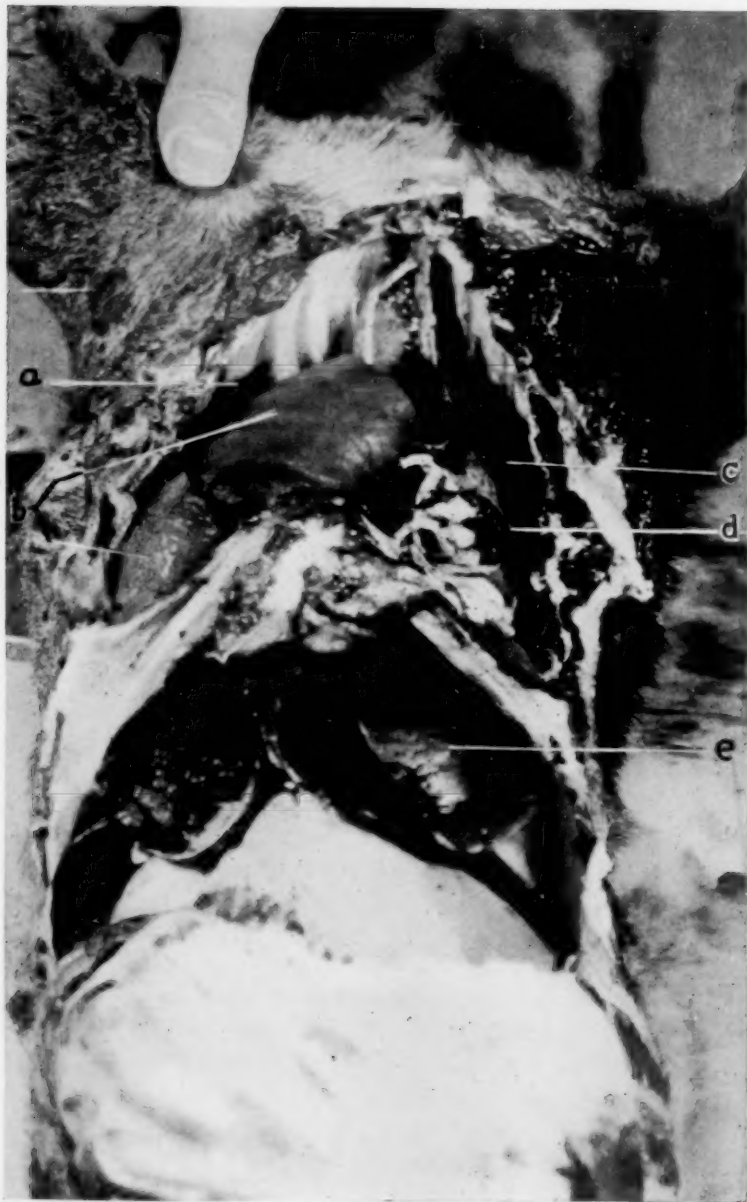


FIG. 6.—Same dog as shown in Fig. 5. Immediately after death it was placed in a refrigerator for three hours to allow the agar to solidify, and the chest wall was then opened as shown in the photograph. A represents the right pleural cavity, which was found to be of practically the same size as the left pleural cavity C. At B is shown the mass of solidified agar which occupied most of not only the right pleural cavity but also pushed the mediastinal structures over into the left side of the thorax. At D is the heart which nearly touched the left lateral wall of the thorax. E shows the liver. The right lung was found encased in the agar and lying against the posterior wall instead of being contracted into a small mass about the hilum, as is generally supposed to happen when the lung is compressed. The left lung was also crowded against the posterior wall by the bulging over of the heart and other mediastinal contents. This experiment affords striking confirmation of the idea of practically an equality of pressure throughout the normal thorax at all times.

It is for this reason that, as will be shown later, it is desirable often to examine a patient not only for an acidosis but also for conditions of associated diminished kidney excretion.

Other effects of asphyxia will be mentioned briefly, such as changes in the nature of the act of respiration, the effects on muscles, and the occurrence of glycosuria. In cases of acidosis the pulmonary ventilation is increased by a greater amplitude and also by a greater rate, constituting sometimes even a condition of "air-hunger." All the evidence seems to indicate that this change in the type of respiration is due to the influence on the respiratory centre of  $\text{CO}_2$  and other acids and their resulting minute effect on the hydrogen-ion concentration of the blood rather than to a lack of oxygen.

The response of the muscles to the effects of asphyxia is of special interest to surgeons. Contractions usually occur which are often very violent. This phenomenon is seen in a striking manner in cases of severe strangulation, in which there are general convulsions of the opisthotonus type. The unstriated muscles also react in a similar way, as shown by the excessive peristalsis and the strong uterine contractions which often accompany a state of general or local asphyxia. They are seen to a less marked degree in the twitchings and tremors of the extremities during an incomplete or poorly conducted anaesthesia. These phenomena were studied experimentally by the author<sup>38</sup> several years ago and were made the basis of a suggestion of the origin and nature of fetal movements. The effects on the blood-vessels are also important and are of two kinds, depending upon whether the vasomotor centre in the medulla and the spinal centres are involved, or whether the asphyxial process is confined more locally. In the former case the response is a general vasoconstriction with a resulting rise in blood-pressure which will gradually drop as the severe state of asphyxia persists. All the evidence is in favor of the idea that this phenomenon is the result of the action of  $\text{CO}_2$  and other acid substances rather than merely to a lack of oxygen. In the second case, in which the asphyxial process is confined to a local region without an associated effect on the vasomotor centres, the usual response is a marked dilatation of the blood-vessels. By this means the blood-flow through the part is greatly increased. Here again the evidence strongly indicates that acid substances in the part ( $\text{CO}_2$  and lactic acid) are important agents in the production of the phenomenon. The evidence for this view is based largely on the work of Gaskell and Langley,<sup>39</sup> Bayliss,<sup>40</sup> Schwarz and Lemberger,<sup>41</sup> Ishikawa,<sup>42</sup> Starling,<sup>43</sup> and Hooker.<sup>44</sup> Recently Woolley<sup>45</sup> has sought to correlate these facts to the vascular dilatation which occurs in inflammation.

The occurrence of glycosuria in asphyxial conditions is an old observation, apparently having been made originally by Richardson<sup>46</sup> in 1862 in experimental carbon monoxide poisoning. It was largely Araki,<sup>33</sup> however, who showed that glycosuria may be present in any condition in

which there is a diminution in the supply of oxygen to the tissues. It occasions no surprise, therefore, that frequently after a prolonged anæsthesia there is a transient glycosuria.

*Application of a Knowledge of the Effects of Asphyxia to Clinical Conditions.*—There are very many surgical conditions in which the effects of asphyxia are conspicuous. I shall discuss only a few in which they are especially prominent. As has been mentioned above, the general narcotic agents belong to a group of substances the effect of which is to diminish oxidations in the tissues and thereby to induce a condition of asphyxia. It is important that some detailed consideration be given to this point. Of the agents most commonly employed to produce general surgical anæsthesia or narcosis, all the evidence at hand shows conclusively that chloroform is the most powerful in causing asphyxial effects and that nitrous oxide is the least harmful in this respect. Ether occupies an intermediate position. This knowledge has led to an almost complete abandonment in America of chloroform as an anæsthetic agent and the substitution for it of ether or nitrous oxide. The use of the latter has been popularized very largely by the work of Crile. Woodyatt and Sansum<sup>47</sup> have shown in a very striking manner that in dogs made completely diabetic by phlorizin it is almost impossible to produce narcosis by chloroform without death but that the tolerance for ether is very much greater than for chloroform and that a narcosis with nitrous oxide can be maintained for a period of hours without death even in such animals. One of the most striking features about chloroform is that its toxic effects may not culminate in death until two or three days after its administration, at which time almost all of the cardinal features of a severe asphyxia may be present. For example, the pathological syndrome, of which we have already spoken, of œdema, fat infiltration, hemorrhages and necrosis are conspicuous, and in addition other features such as an acidosis, the occurrence of acetone and products of deficient oxidation in the urine, etc. One of the first to call attention to this condition was Guthrie<sup>48</sup> in England in 1894. Since that time many notable contributions have been made. For a full discussion of the literature the reader is referred to the articles by Bevan and Favill,<sup>49</sup> Wells,<sup>50</sup> Whipple and Sperry,<sup>51</sup> and Howland and Richards.<sup>52</sup>

Having become interested in the question of why chloroform should be more toxic than the other anæsthetic substances, the writer in 1915<sup>53</sup> published some observations based on experimental work which indicated very strongly that chloroform is decomposed in the body in such a way as to yield hydrochloric acid. This property of decomposing to yield the corresponding halogen acid is shown not only by chloroform but it appears to be a general characteristic of that group of substances which is known chemically as the alkyl halides. This group includes such substances as iodoform, ethyl chloride, ethyl bromide, ethyl iodide, etc. Each of these is decomposed in the body with the liberation of its corresponding

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halogen acid, hydrochloric, hydrobromic or hydriodic, as the case may be. On the other hand, ether and nitrous oxide are incapable of yielding a strong mineral acid in their breakdowns within the body. These facts offer a ready explanation of the increased toxicity of chloroform over these latter substances, and they show at once the great danger to which a patient is always subjected when given chloroform. This danger is correspondingly increased if he is already suffering from an acidosis or from any other effects of an impaired tissue respiration. Chloroform is, therefore, particularly interdicted in severe acute infections, in diabetes, in conditions of impaired kidney function, in thoracic surgery in general, in conditions of starvation with acidosis, etc. From the standpoint of minimizing the effects of disturbed tissue respiration, the evidence is overwhelming that the safest general anæsthetic agent is nitrous oxide when combined with oxygen and when given by a skilled anæsthetist. Ether occupies an intermediate position between nitrous oxide and chloroform.

Other surgical conditions in which the effects of disturbed tissue respiration are conspicuous are severe hemorrhage and secondary traumatic shock. In one case oxygen carriers are completely removed from the body and in the other they are removed, at least temporarily, from the active circulation. Erlanger and Gasser<sup>54</sup> have shown that apparently one of the constant and important features of the pathology of shock is that the capillaries and venules of the intestinal villi are enormously distended by solid masses of red corpuscles. There is usually a marked reduction in the reserve alkalinity of the blood, and Cannon<sup>18</sup> and others have emphasized the importance of the factor of an acute acidosis in this condition. Erlanger has shown, however, that shock is probably not essentially an acidosis, since the degree of shock and the extent of the acidosis are often far from proportional. With a view of combating the acidosis Dawson<sup>55</sup> in 1905, and Seelig, Tierney and Rodenbaugh<sup>56</sup> in 1913 employed alkalis in shock.

In cases of severe acute anæmia from hemorrhage practically all of the various classical signs of tissue asphyxia may be observed. These often, however, rapidly disappear, so that within a few days they may no longer be present. Mohr<sup>57</sup> has suggested that the fulfillment of the oxygen requirements in anæmia is due in part to an improved utilization of oxygen, as well as to an increase in the velocity of the blood-flow associated with a rise in the systolic output of the heart.

In cases of intestinal obstruction and in acute dilatation of the stomach, the classical features of tissue asphyxia are usually strikingly shown, at least locally. If the clinical picture of obstruction is due to a sudden occlusion of the circulation to the part, as, for example, in a mesenteric thrombosis or embolism, excessive peristalsis, as an effect of asphyxial acids, may precede the period of absence of peristalsis. Later the usual features of œdema and hemorrhage appear with finally necrosis. But even in cases in which the obstruction is not due to conditions which

frankly occlude a large artery or vein, it is nevertheless the disturbance in the circulation, and therefore in the oxygen supply of the affected tissues, that is chiefly responsible for the important effects. Even the excessive peristalsis which is practically always observed may be the response to the local acidosis. Extensive experimental evidence has been accumulated by American workers to show that the disturbances of the circulation are much more important in producing early severe symptoms and death than is the obstruction itself. The extensive œdema and extravasation of blood in these cases are conspicuous characteristics of the asphyxial process. These facts have especially been brought out in the excellent experimental work on intestinal obstruction by Murphy and Vincent,<sup>58</sup> Hartwell and Huguët,<sup>59</sup> Whipple, Stone and Bernheim,<sup>60</sup> Murphy and Brooks,<sup>61</sup> and by Brooks, Schumacher and Wattenberg.<sup>62</sup>

In the condition of acute dilatation of the stomach, Woodyatt and myself<sup>63</sup> several years ago produced experimental evidence that here also the question of the asphyxia of the stomach wall is more responsible for the characteristic features than is the element of obstruction. This conclusion was based on the facts that, (1) a condition practically identical with acute dilatation of the stomach can be produced experimentally in dogs by measures which restrict its oxygen supply and (2) that an analysis of the gaseous and fluid stomach contents of such cases (both in the human and in the experimental animals) reveals products which are known to arise in disturbed oxidations. For example, the gas is chiefly CO<sub>2</sub> and the fluid contents contain much extravasated blood. The whole process seems to consist of a severe bloody œdema of the wall of the stomach with the extravasation of the fluid and gas chiefly into the lumen of the stomach.

Another clinical application of asphyxia as a cause of disease concerns that group of conditions sometimes spoken of as the hemorrhagic diseases of the newborn. It includes those affections of the newborn which are characterized by excessive fatty infiltration of the liver, œdema, a hemorrhagic tendency, and sometimes an associated icterus. Two of this group of affections are often referred to as Buhl's and as Winckel's diseases. It is interesting, however, that the former was described as early as 1813 by John Cheyne<sup>64</sup> and again independently in 1852 by Minot<sup>65</sup> of America, both of whom antedated Hecker and Buhl, and that the latter condition was described by the Frenchman, Parrot,<sup>66</sup> in 1873, six years before Winckel, by the Frenchmen, Laroyenne and Charrin,<sup>67</sup> in 1874, and by the American, Bigelow,<sup>68</sup> in 1875. In 1912 the writer<sup>69</sup> called attention to the marked resemblance which these conditions bear to an asphyxial process and showed by experiment that in guinea pigs all the characteristic features of these diseases could be produced by applying measures to the pregnant animal which would induce a severe asphyxia of the fetuses. It was considered likely that, in the human, protracted asphyxia of the foetus both from mechanical causes and from the use of chloroform during labor must be the origin of many of these cases.

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### PART III

#### THE RECOGNITION OF ASPHYXIAL EFFECTS

Those effects of asphyxia which result in definite pathological lesions can, of course, be recognized by gross and microscopical examination of the affected tissues. The other type of effects, the physiological disturbances, usually require chemical methods for their detection. I shall discuss the principles rather than the details of these methods, since the latter are readily available in the literature. Of these physiological disturbances one of the most important is the phenomenon of acidosis, since most of the others are more or less intimately related to this condition. There are two clinical tests of some value in the recognition of a pronounced acidosis. One of these is the fruity odor of acetone on the breath. The other is the inability of the patient to hold his breath for more than a few seconds. Stange<sup>70</sup> noted that a patient who can hold his breath for only twenty seconds or less is a bad risk for a general anæsthesia. Although he attributed this fact to an impairment of the myocardium, Yandell Henderson<sup>71</sup> later attributed the phenomenon to an existing acidosis and elaborated upon it as a convenient clinical test. The other methods of detecting acidosis have been outlined by Sellards<sup>72</sup> in an attempt to group them in the order in which they might be expected to occur in the gradual development from normal conditions to a state of advanced acidosis. His outline is as follows:

1. Appearance of acetone bodies in the urine (for carbohydrate acidosis only).
2. Increase in tolerance to sodium bicarbonate.
3. Lowering of the carbon dioxide of the alveolar air and of the blood.
4. Change in reaction to phenolphthalein from alkaline to neutral of protein-free filtrate from blood serum.
5. Increase in output of ammonia in urine (usually normal in nephritic acidoses).
6. Increase in hydrogen-ion concentration of the blood.

Any one of these tests when taken alone has certain drawbacks in the recognition of acidosis, and the diagnosis should be supported by more than one. The appearance of acetone bodies in the urine, for example, is an indication only of impaired fat metabolism, and furthermore, the absence of acetone does not necessarily imply the absence of an acidosis even of the type arising from a disturbance of the carbohydrate metabolism. A discussion of this question in relation to the acidosis of children is given by Howland and Marriott.<sup>73</sup> The increased tolerance to bicarbonate, which was used by Sellards in the recognition of acidosis, is said by him to be the most delicate of the tests which are specific. Under normal conditions the ingestion of sodium bicarbonate in as small an amount as 5 grams is soon followed by the excretion of some of this in the urine with the result that its reaction changes from acid to alkaline. In cases

of Asiatic cholera with nephritis, Sellards found that the urine frequently remained acid even after the intravenous injection of as much as 90 grams of the bicarbonate, whereas the injection of from only 3 to 5 grams in the normal was sufficient to render the urine alkaline.

The determination of the carbon dioxide tension of the alveolar air and of the blood is of very great value. For the former a very simple clinical method has been devised by Marriott.<sup>74</sup> For the latter the method most commonly used in America is that of Van Slyke, Cullen and Stillman.<sup>75</sup> A slight decrease, however, of the carbon dioxide tension of the alveolar air is not necessarily indicative of an acidosis; for, as Marriott, Sellards and others have emphasized, this may be lowered by an increased pulmonary ventilation and also by any change in the lungs or in the circulation which would interfere with the exchange of gases between the alveolar air and the blood. The change in reaction to phenolphthalein of the protein-free filtrate of the blood from alkaline to neutral has been suggested by Sellards as a convenient clinical method which possesses advantages over ordinary titration methods. It is fully discussed in the article by Sellards.<sup>76</sup> The study of the urinary output of ammonia has yielded results of the greatest fundamental importance in the development of our knowledge of diabetes and of disturbed carbohydrate and fat metabolism, but its value is inferior to some of the other tests in the recognition of an acidosis of a different type or where there is an associated impaired urinary excretion.

The determination of the hydrogen-ion content of the blood is now regarded in America as being of very little clinical importance. As has been said before, the reaction of the blood is one of the most constant and unalterable phenomena of the body. It is reasonable to suppose, therefore, that only the most extreme degree of acidosis would be accompanied by changes sufficient to be detectable. Experience has confirmed this. Of the American workers, Benedict<sup>77</sup> and Peabody<sup>78</sup> have been among the first to show it.

As has been stated elsewhere in this article, the phenomenon of acidosis is often intimately concerned with the question of renal excretion, especially because one of the most important routes of elimination of acid substances is by way of the urine. Certain clinical tests are therefore of value in determining the degree of impairment of the kidney function. Two methods, commonly used in America, which have been found to be particularly valuable in genito-urinary surgery are, (1) the method of Folin<sup>79</sup> for the determination of the non-protein nitrogen of the blood and (2) the rate of excretion of dyes, especially of phenolsulphonephthalein, as suggested by Rowntree and Geraghty.<sup>80</sup> The former test is based on the fact that in conditions of impaired renal function the elimination of non-protein nitrogenous products, as well as of other substances, is reduced and that therefore an accumulation of them in the blood occurs. These products include such known substances as urea,

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ammonia, uric acid, creatin, creatinin and the amino acids. Normally, they occur in an amount of from 25 to 30 milligrams in 100 c.c. of blood. In cases of marked impairment of renal function, as, for example, in threatened uræmia in prostatic obstruction, the amount of non-protein nitrogen in the blood may reach the high figure of 100 or more milligrams per 100 c.c. It is necessary to emphasize, however, that an exact knowledge of the diet is of the greatest importance in the interpretation of values in the above test. In regard to the determination of the excretion of dyes, the one most frequently employed in America, the phenolsulphonephthalein test, is based on the fact that in conditions of impaired renal function the rate of excretion is reduced. For details of the method the original article should be consulted. In normal individuals, if 1 c.c. of a solution containing 6 mg. of phenolsulphonephthalein is injected subcutaneously, from 40 to 60 per cent. of the dye is excreted within the first hour and from 60 to 85 per cent. is eliminated within the first two hours. In nephritic cases, particularly in threatened uræmia, the excretion of the dye may be as low as from 5 to 10 per cent. in the first hour.

*Some Practical Methods of Minimizing the Effects of Asphyxia.*—With the knowledge before us of the various ways by which asphyxia may be produced we can more certainly avoid the occurrence of asphyxial effects. Likewise in any condition in which a state of asphyxia is already pronounced we should scrupulously avoid any measures which would tend to aggravate it. This would imply that in any condition in which, for example, the oxygen intake is impaired, as in the early stages of an empyema, it should be remembered that the creation of an open pneumothorax for drainage, the use of a general anæsthetic agent (especially chloroform) will necessarily tend to increase the asphyxial effects. Also in conditions in which oxidations are already disturbed, as in diabetes, it is imperative that any anæsthetic agent used should increase those effects as little as possible. For this reason it would seem that chloroform should have no place in operations performed in the presence of such conditions. Likewise, in cases of acidosis with impaired renal function there is no doubt that chloroform is the most dangerous of the common anæsthetic agents. The idea which is sometimes expressed by surgeons that chloroform is less dangerous than ether in nephritic conditions is contrary to all the evidence available on the subject. The administration of chloroform particularly, and of ether to a less extent, is frequently followed by an increase of the urinary ammonia and by the occurrence of acetone in large quantities. It is an old observation that this effect is diminished if an abundance of carbohydrate has been ingested previously. Beddard<sup>81</sup> has recommended the generous administration of carbohydrates to avoid "delayed chloroform poisoning." Opie and Alford<sup>82</sup> also have shown that in mice the feeding of carbohydrates exerts a decidedly protective action against the development of liver necrosis by chloroform. In 1915 the writer<sup>83</sup> showed that the normal

relative insusceptibility of young pups to chloroform poisoning is due, at least chiefly, to the high glycogen content of their livers. These observations are all in accord with those of Roger<sup>84</sup> in 1892 on the protective action of the liver against strychnine and with those of Rosenfeld<sup>81</sup> that animals fed upon carbohydrates are in general less susceptible to all those substances which produce fat accumulation in the liver. Of interest in this connection are the recent observations of the writer in association with Helen T. Graham<sup>85</sup> that sugars as a class retard the diffusion of acids through gelatin. It is well known that as long as a diabetic is oxidizing an average of 75 grams of carbohydrate in twenty-four hours the urine is free from  $\beta$ -oxybutyric and aceto-acetic acids, although it may contain small amounts of acetone.<sup>86</sup> The importance, therefore, of insuring that the liver is well supplied with glycogen by the administration of carbohydrate previous to undertaking an important operation is obvious. Conversely it is also obvious that a practice, still somewhat prevalent, of starving a patient for several hours before the operation and of withholding all food after the operation for two or three days, is dangerous. Glucose can be administered almost immediately after the operation to practically all patients by the rectum or in a 2 or 3 per cent. solution subcutaneously. It may also be given to advantage intravenously in concentrations of 5 per cent. or greater.

In conditions of already established acidosis of any type the administration of alkali in the form of sodium bicarbonate is helpful. Caution should be exercised, however, in the intravenous injection of it, for the reason that excessive quantities of alkali are in themselves toxic. The use of the bicarbonate should be controlled by a careful watch of the urine and should never be pushed beyond the point of neutrality or of slight alkalinity of the latter.

Another important matter is the copious administration of water. In order to insure the maximum elimination of acid it is essential that the urinary output be maintained to as nearly a normal degree as possible, or even to exceed the normal urinary elimination. Recently Woodyatt, Sansum and Balcar<sup>87</sup> have obtained striking evidence in favor of the view that fever is often an expression of a lack of "free" water in the body. Their work again serves to emphasize the importance of maintaining the water balance of the body. They emphasize also the desirability of giving fluids in the form of glucose solutions, because not only does the glucose itself provide food and exert an antiketogenic action, but also because "free," unbound, water is available after the sugar is consumed.

#### SUMMARY

Since respiration is one of the most fundamental properties of living matter, any interference with it leads to widespread and severe changes. By asphyxia in this article is meant not only an interference with the intake of air into the lungs, but also any disturbance in the free inter-

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change of oxygen and carbon dioxide in the tissues and any disturbance of oxidative processes which results in the formation of abnormal amounts of products of incomplete oxidation.

Asphyxial conditions may therefore be produced in any of the following ways: (1) An interference with the intake of air, (2) an interference with the power of the blood to carry oxygen or to remove carbon dioxide, (3) an interference with the circulation of the blood, and (4) a disturbance of the power of the tissues to utilize oxygen. All of these factors are of interest to the surgeon, and he may encounter all of them even in the same patient.

Interference with the intake of air is the result of not only obstructions of the upper air-passages but also of pulmonary disturbances which give rise to a diminished alveolar surface. These latter disturbances are due both to changes within the lungs, such as inflammatory exudates, and to abnormal pressures outside the lungs which limit their normal expansion. The principal agents which restrict the expansion of the lungs by pressure, are air and fluid.

The disturbances within the thorax which are caused by abnormal changes of intrapleural pressure are discussed in detail from the standpoint of new experimental work, as a result of which it seems evident that the previous, commonly accepted ideas are incorrect.

From the standpoint of pressure relationships the normal thorax may be regarded practically as one cavity instead of two. Any change of pressure in one pleural cavity is accompanied by practically an equal change in the other, so that an equilibrium of pressure exists at all times throughout the whole thorax.

The prevalent conceptions of pneumothorax are erroneous in that they are based on the assumption that when an opening is made into the chest one lung is collapsed and the other maintains respiration. This assumption implies that the mediastinum constitutes a rigid partition between the two pleural cavities. On the contrary, the mediastinum in the normal thorax is so mobile that any increase of pressure in one pleural cavity pushes it over into the opposite one so that both lungs are compressed practically equally. If, on the other hand, the mediastinum has been made rigid by induration as a result of long-standing inflammation, or if it has become fixed by adhesions, then a pleural opening on one side will not produce the same pressure changes in both pleural cavities.

The maximum opening into a pleural cavity which is compatible with life depends upon a definite relationship which exists between the amount of air entering the lungs and the amount entering the pleural opening. The maximum opening compatible with life may be approximately determined for the normal chest by the mathematical expression given in the text. By this mathematical expression it is found that an average normal man should be able to withstand for a short time an opening of about 64.8 sq. cm. (10 square inches); one with a "vital capacity" greater than

the average will be able to withstand a larger opening. There is harmony, therefore, between these results and the finding at the front that men were able to maintain respiration with gaping thoracic wounds which seemed surprisingly large.

A double open pneumothorax in a normal chest is more dangerous to life than a unilateral open pneumothorax merely because usually the combined areas of the two openings (and therefore the amount of air admitted into the pleural cavities) is greater than a single opening on one side is likely to be. Theoretically and experimentally effects of practically the same severity result in the case of one or more openings into one pleural cavity as follow the creation of a double pneumothorax, provided that in each case the combined areas of the various openings are equal.

The bearing of these results and deductions upon both the treatment of acute empyema and upon thoracic surgery in general is obvious. Whenever the amount of air taken into the lungs is limited by the presence of an active pneumonia, with plugging of both air channels and alveoli, whenever there is an excessive demand for air, whenever there is a sufficient weakening of the respiratory muscles to impair compensation, or, in short, whenever there is a marked reduction in the "vital capacity," the size of a pleural opening compatible with life becomes smaller; and if any or all of the above factors are present in sufficient intensity, even a very small opening into the pleural cavity will produce death from asphyxia. Since all of these factors are likely to be present to a high degree during the early stage of an empyema of the streptococcus type, early operation with the establishment of an open pneumothorax carries with it an unwarrantable danger. Either a method of repeated aspirations or one of closed drainage is indicated until after the above dangerous factors have disappeared.

Interference with the ability of the blood to carry oxygen or to remove carbon dioxide is of interest to surgeons chiefly in connection with anæmia, both acute and chronic, and perhaps rarely in poisonings of the type of carbon monoxide poisoning.

Interference with the circulation of the blood is of surgical importance not only locally in connection with the ligation or destruction of an artery, but also in heart disease, in shock, and in pneumothorax.

An inability on the part of the tissues to utilize oxygen is seen especially in narcosis with the common general anæsthetic agents and also in intoxications with acids, cyanides, etc.

The effects of disturbances of tissue respiration are both anatomical and physiological. The former consist, in general, of the syndrome of œdema, fat infiltration, hemorrhages, and necrosis. The physiological disturbances comprise the phenomenon of so-called "acidosis," changes in the respiration, glycosuria, etc. The importance of an impaired kidney function as a factor in the production of an "acidosis" is emphasized and discussed.

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The applications of these ideas to various definite surgical conditions are discussed, as, for example, in surgical narcosis, in intestinal obstruction and acute dilatation of the stomach, in shock, etc.

The principles underlying the recognition of many of these effects are discussed, as well as methods of minimizing them.

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## SOME UNDERLYING PRINCIPLES OF INTESTINAL AND GASTRIC SURGERY\*

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SURGICAL operations are done on living tissue and should be considered from this standpoint. Naturally, a knowledge of anatomy is essential, but merely following anatomical landmarks and making a beautiful dissection with accurately placed ligatures and sutures should not be the sole aim of the surgeon. This, to be sure, is properly included in the surgeon's ideals, but it is even more important that an operation shall result in the extirpation or correction of the pathology and in the restoration of the physiology of the tissues or organs involved. The physiology and pathology in the living are the chief biologic processes that should concern us in the planning of any operative procedure. It is often true that a patient may recover when but little regard is paid to these things, but the success of an operation should not always be judged by the fact that the patient survives. The eventual morbidity as well as the present mortality should be considered.

The biologic processes that follow surgical procedures are often given scant attention. Surgical drainage, for instance, is frequently regarded as solely or chiefly mechanical, though its action is largely biologic. The treatment of fractures by metal plates or screws produces beautiful immediate mechanical results, but a little study of the biologic processes that follow the use of steel plates and screws in bone should convince the surgeon that this is not a satisfactory operation. The effort to reverse the circulation of the blood by switching the arterial current into the veins has not been successful. Apparently, this was considered largely from a mechanical viewpoint, with the expectation that the continual pounding of the arterial current would break down valves that withstood the immediate arterial pressure. If the body were working solely on the principle of a machine, this would, of course, happen sooner or later. But it is a well-known physiologic law that when unusual work or strain is thrown on tissue or organs, one of two things happens: either the tissues or organs break down, or else they hypertrophy to meet the strain. This is what happens in attempted reversal of the circulation, as it can be determined experimentally that the valves of veins in an animal which do not break down in the first few minutes, apparently hypertrophy and form a permanent obstacle to the arterial current. Weeks after the reversal of the circulation, examination will show that the arterial current

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has gone no farther in the main trunk of the vein than it did the first few minutes after it was turned on.

The value of regarding the laws of physiology in surgery of the intestines and stomach is impressive. In the last two decades much has been discovered in the physiology of the stomach and intestines. The work of Keith, of Cannon, and of Sherrington, is of the greatest interest and has much practical bearing upon surgery. G. K. Dickinson, of Jersey City, has recently published an excellent discussion of the present views on the embryology and physiology of the intestines in a paper entitled "The Myenteric Nerve Net" (*Journal A. M. A.*, February 14, 1920, pp. 442-445). The value of preserving the physiologic functions of peristalsis becomes more evident with our increased knowledge of this subject. The obvious function of peristalsis is to propel fecal contents, but the action of the small regular peristaltic waves in emptying the branches of the veins and lymphatics in the walls of the bowel is highly important.

The obvious result of abolition of peristalsis of the bowel is obstruction. The cause of death in obstruction is undoubtedly due to toxæmia, though whether the toxic material is formed in the mucosa or within the lumen of the bowel is still a subject of some controversy. It is well known, however, that when mechanical obstruction has reached the point where there is distention and but little peristalsis, the condition of the patient is critical. It is also well known that handling of the bowel or exposure of its surface promotes intestinal paresis or paralysis. This may partly be due to evaporation of the carbon dioxide, as without the stimulation of carbonic acid in the substance of the intestinal wall the nerve net there ceases to act. Probably the direct handling and trauma incident to moving the intestinal coils in obstruction act also as an inhibitive factor for peristalsis. In obstruction of mechanical origin, nature's first effort is to overcome the obstruction by increasing the strength of the peristaltic waves. Naturally, after a time the musculature of the intestine becomes exhausted and eventually, if the obstruction is not relieved, the muscle is paralyzed from exhaustion and death ensues.

The old rule that in operations for obstruction the intestine must not be returned to the abdominal cavity until it has been thoroughly emptied has probably been the cause of much mischief. It is this unwise practice that has been responsible for the introduction of glass or metal tubes through an opening in the bowel and the threading of almost the whole length of the small intestine on such a tube in order to empty the bowel as far as the upper jejunum. This practice disregards the physiology of the intestines and particularly the physiology that occurs after obstruction. Even the opening of the abdomen under a general anæsthetic is followed by temporary paresis of the bowel. This may be a protective phenomenon intended to keep the bowel quiet so that a neighboring loop or omentum may plaster over the injured portion of the intestine and so prevent infection. It also provides physiologic rest. At any rate, the

phenomenon is commonly observed and is more pronounced with increased handling of the viscera. If, then, the whole length of the small intestine is forcibly threaded over a rigid tube, it can readily be imagined that the normal reaction would be a complete abolition of peristalsis for a considerable time. This paralysis of the bowel wall will probably do more harm in permitting the rapid accumulation of gas and of fecal contents from the excretory apparatus of the bowel than the immediate emptying will do good.

If the obstruction has reached such a stage that peristalsis is completely and permanently abolished, nothing can save the patient, but if there is still preserved a weak peristalsis, the performance of an enterostomy with as little trauma and exposure of the bowel as possible relieves the loop of bowel in which the enterostomy is done and will encourage the emptying of other proximal loops that still have sufficient peristalsis to expel their contents when both the pathologic and physiologic obstruction has been overcome by the enterostomy. The physiologic obstruction is obviated by avoiding the necessity of forcing the fecal contents along the normal intestinal tract below the enterostomy. But if a considerable portion of the bowel has been threaded over a metal tube, the manipulation of the intestine may completely abolish the weak effort at peristalsis that still remains. It is in such cases that an enterostomy with a rubber catheter, performed above the point of obstruction, gives the maximum chances of recovery.

For several years I have been doing an enterostomy that has given much satisfaction. It may usually be done under local anæsthetic and requires the delivery of only a few inches of an intestinal loop. If the loop is greatly distended and cannot be readily delivered, the method of J. W. Long is satisfactory, but the distention may often be overcome by packing around the coil and emptying the gas with an aspirating needle. In obstruction from mechanical causes there is a marked hyperæmia and often considerable free fluid in the peritoneal cavity. This gives a high degree of immunity against infection and even considerable soiling of the peritoneum under these conditions is harmless.

After delivery of the loop of intestine, intestinal clamps are placed about six inches from each other and the border of the bowel is grasped with mosquito forceps or Allis forceps about two inches from one of the clamps. A similar point is fixed near the other intestinal clamp, and while traction is made on these forceps to make the bowel between them taut, the bowel is incised. This should be done with a sharp knife and should go down to, but not through, the mucosa. The incision is two inches long. After separating the peritoneal and muscular coats from the mucosa, a purse-string suture of linen is placed at one end of the incision and the mucosa within the grasp of this purse-string suture is punctured. A medium-sized soft-rubber catheter, in which there are one or more additional perforations, is quickly inserted through this

puncture and the purse-string suture is tied snugly around the catheter. One end of the purse-string suture then transfixes the catheter to hold it in position. The catheter is buried on the exposed mucosa in the incision with a continuous right-angle suture. Before the catheter is inserted, it should be clamped at its end to prevent soiling. The loop of bowel may be confidently returned into the abdomen without fear of leakage. The enterostomy wound, however, should be near the parietal peritoneum. The catheter is fixed to the abdominal wall with adhesive to prevent unnecessary traction upon it. It is connected with a container in the usual manner. Through this catheter gas and fecal contents are easily emptied from the bowel, and peristalsis has not been interfered with in the other loops of the intestine. After ten days the catheter readily comes away and the valve-like mucosa, which has been formed on the principle that Coffey has enunciated in transplantation of the ureter or common bile-duct, will in many cases prevent the exit of fecal contents after the catheter has been withdrawn. Even when faeces flow for a few days, the amount is small and soon ceases.

The operation of lateral intestinal anastomosis is admitted to be physiologically wrong, even by its most ardent supporters. The work of Cannon and Murphy (*ANNALS OF SURGERY*, vol. xliii, pp. 519-520) has conclusively shown that in lateral anastomosis peristalsis in the region of the anastomosis is practically abolished, and food can be pushed through the anastomotic opening only when a column of it extends into a proximal (oral) loop where peristalsis is unimpaired. This is true because severing the circular muscular fibres in lateral anastomosis abolishes peristalsis in that region and the blind pouches at the ends cannot be completely emptied. These investigators found that in end-to-end union of the intestine there is not the slightest stasis of intestinal contents at the site of operation. Many patients with a lateral anastomosis are able to overcome the handicap of the unphysiologic procedure and have no symptoms. This, however, is by no means always true, and the cases reported by Moore and others show that the complications following this operation may be extremely serious. (*Transactions Southern Surgical Association*, vol. xxxi, pp. 152-153.)

The chief objection to end-to-end union of the intestine has been that the suture line is likely to leak either at the mesenteric junction of the bowel or at a point opposite to this, where the nutrition is poor. I have elsewhere attempted to show that while the triangular space where the mesentery splits to envelop the bowel has been considered responsible for most of the failures of end-to-end union of the intestine because it is devoid of peritoneum, the real cause for failure is infection. W. J. Mayo has repeatedly stated that for successful union peritoneum is only needed on one side, and this mesenteric space is usually carefully sutured by every operator before the operation is completed. The great trouble is that many surgeons who have had disastrous experiences in end-to-end union,

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infect this area when the lumen of the bowel is opened. They cut the bowel from the free border toward the mesentery and then clamp and suture the triangular space. Dividing the bowel in this manner necessarily carries the contents of the bowel into this space, because the blades of the scissors that cut through the lumen of the bowel must be contaminated with fecal contents and will smear bacteria into this space. When the operation is completed, this region is carefully sutured and later, when leakage occurs here, it has been assumed that the leakage is due to lack of peritoneal covering. If we were to dip a platinum loop into fecal contents and smear it into an incised wound on the hand, and then later suture the wound very carefully, we would not be surprised when the sutures broke down. It is for the same reason that leakage occurs at the mesenteric triangular space, which is composed of loose tissue, rich in lymphatics and small blood-vessels, and when once infected can hardly be sterilized.

Another point of leakage is at the border opposite the mesenteric border, and here, if the nutrition has been preserved and the infection is not overwhelming, leakage should not occur, provided the sutures have been properly placed. The ends of the bowel before suturing should be cleaned, using gauze wet with antiseptic solution and making an effort to disinfect the mucosa of the intestine in the same general manner as we would the skin before incising it. It may be impossible to sterilize the mucosa of the intestine, just as it is impossible to sterilize the skin by any known method that does not destroy the skin, but certainly the majority of the bacteria can be removed, and then the needle and thread will not carry the infection as they do if the fecal matter is simply squeezed out and no further effort is made to clean the bowel ends. Leakage opposite the mesenteric border in end-to-end union of the colon may be due to lack of cleaning the bowel ends, and so preventing infection where the nutrition is weakest. If the colon is not made as nearly aseptic as possible, when the thread pierces its lumen it carries bacteria through the whole tissue. This may account for the poor healing and the late infection of the stitches that have sometimes been noted after resection of the colon. If the end of the bowel is cleaned, fecal matter when turned on after removing the intestinal clamps will only contaminate that portion of the thread within the lumen, and there is less chance of infection from the thread that is already buried in the tissues of the bowel wall.

Then, too, end-to-end union after resection for cancer of the colon permits removal of more of the bowel than lateral anastomosis, which is sometimes a great advantage.

In an effort to overcome these objections, I have worked out a method for resection of the small intestine which in my hands has been quite satisfactory (*Southern Medical Journal*, vol. viii, p. 298). According to this technic, the loop containing the diseased bowel is clamped and emptied as far as possible. The mesentery is first divided close to the

bowel and the triangular space at the bowel is clamped and tied. The rest of the mesentery is then divided and its vessels are tied. Moist gauze is packed under the loop and the proposed site of resection is carefully isolated with moist gauze. After clamping the loop near the proposed point of resection, the bowel is cut somewhat obliquely from the mesentery outward. The end of the bowel is carefully cleaned with gauze

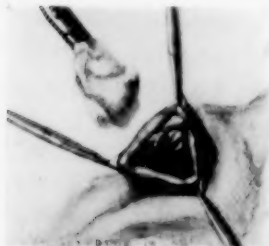


FIG. 1.—After the mesentery of the bowel has been divided and tied, and the triangular space at the mesenteric border closed with a ligature, the bowel is divided from below upward. The end is carefully surrounded by moist gauze caught with forceps and cleaned out with gauze wet with an antiseptic solution.



FIG. 2.—The suturing is begun by a mattress suture, the short end of which is left clamped and the long end continued across the mesenteric border of the bowel. Care is taken to include the stumps of the ligated triangular space in this suture. When a third of the circumference has been sutured, the thread is changed to a right-angle continuous stitch.

dipped in bichloride solution (Fig. 1). The other end of the loop is cut away and the end of the bowel similarly cleaned. The bowel ends are united by a linen or silk thread on a straight needle, which begins as a mattress suture with the knot on the mucosa of the right-hand end. This is continued back and forth across the mesenteric portion, going well below the margins of the bowel with the sutures snugly drawn. When

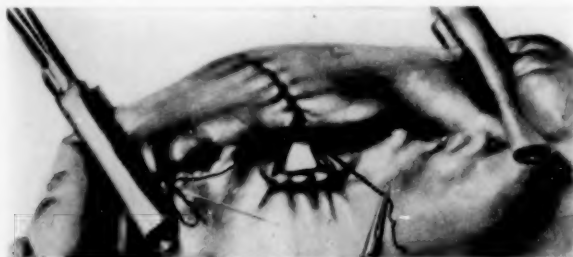


FIG. 3.—The suturing has been completed and the threads are about to be tied.

about one-third of the circumference of the intestine has been sutured, the needle is brought through from the lumen of the bowel to the peritoneal surface and a back stitch is taken. The rest of the suture is completed as a right-angle, continuous suture, turning in a small margin of the bowel with each stitch penetrating to the lumen in order to secure a firm hold (Fig. 2). A back stitch is taken at every third or fourth stitch. When the point of beginning has been reached, one stitch farther is taken

beyond the point of commencement and on the left side of the bowel if the knot is on the right side (Fig. 3). The suture is then tied snugly three or four times to the original short end which was left clamped, and the ends are cut short.

In resection of the cæcum and ascending colon, the same general principles are involved, except that it seems wise to follow nature's lead and provide a valve similar in action to the ileocecal valve which will prevent the flooding of the lower portion of the small intestine by the contents of the colon with each retrograde peristaltic wave. This is carried out by a modification of the end-to-end operation which has just been described (ANNALS OF SURGERY, January, 1919, pp. 25-30). After mobilizing the bowel and separating the mesentery, a suture is begun from the colon side, and instead of uniting the edge of the colon to the edge of the ileum, it unites the edge of the colon to the ileum about an inch back of its end. In this way a small amount of the ileum projects into the lumen of the colon and the external longitudinal fibres pull back the mucosa as a cuff, so that but little peritoneal surface of the ileum is exposed in the lumen of the colon. In this operation, and in all operations upon the large bowel, or where there has been marked obstruction, an enterostomy according to the method described should be done. A small-sized catheter is all that is necessary to give exit to gas (Fig. 4). This may be introduced through a stab wound in the abdominal wall before the catheter is placed in the bowel, and if the end is clamped there will be no occasion for infecting the abdominal wall by the contents of the bowel. In resection of the cæcum, it is wise to surround the line of sutures with omentum, which is always at hand in this region. On the left side in resection of the colon a tube introduced through the rectum and carried through the anastomosis after it has been completed and possibly held in position by a single suture a short distance above the anastomosis, accomplishes the same thing as an enterostomy does on the right side. This suture can be buried by another suture. If the tube is not fastened in this manner it will soon be extruded. The great value of an enterostomy or of a tube through the rectum in resection of the large bowel is because of the distention that follows these operations. This distention not only causes discomfort, but produces so much pressure on the stitches that it retards healing and may cause the stitches to cut. By reducing the pressure the bowel is placed at physiologic rest and in the best condition for healing.



FIG. 4.—Cross section of the completed union between the ileum and stump of the colon after resection of the cæcum and ascending colon. Note the position of the tube, which is inserted from the colon instead of from the ileum as was originally recommended. The valve-like action of the mucosa usually prevents leakage when the tube is withdrawn.

In surgery of the stomach physiologic principles are also valuable. I shall only take up one feature of stomach surgery, the treatment of ulcers of the stomach and duodenum. The usually applied surgical therapy for ulcer of the stomach or duodenum is gastroenterostomy. That this method is not entirely satisfactory from a clinical standpoint alone will probably be evidenced by anyone who studies the ultimate results of his own cases of gastroenterostomy for ulcer, or who goes over the carefully prepared statistics of large clinics, especially if these statistics are written from a medical viewpoint; for it is to the internal medical man that the complaining patient who has undergone gastroenterostomy usually returns. Thus, Frank Smithies, formerly gastroenterologist to the Mayo Clinic, and at present at the Augustana Hospital in Chicago (*Surgery, Gynecology and Obstetrics*, vol. xxvi, March, 1918, pp. 275 *et seq.*), has reported two hundred and seventy-three cases of gastroenterostomy, with only 20.9 per cent. of the patients clinically complaint free. These statistics, too, were in a paper that was not primarily critical of gastroenterostomy.

It is obvious that gastroenterostomy for duodenal or gastric ulcer does not restore the stomach to its normal physiologic condition. It is also obvious, and has been demonstrated by Cannon, Blake and others, that gastroenterostomy is not a drainage operation, and unless the pylorus is closed, some food continues to go by that route. The stomach is doubtless supplied with sensory nerves as shown by Kast and Meltzer, Ritter and others. These nerves terminate in the muscular coat of the stomach and do not reach the mucosa. The pains which come on with such clock-like regularity after meals in duodenal or gastric ulcer are due to the pressure of peristalsis on these gastric nerves which are made unusually sensitive by the inflammation of the ulcer. Consequently, they register impulses of pain from the pressure of peristalsis that in a normal physiologic condition they would not register. The character of the gastric juice has nothing to do with the pain except so far as it excites peristalsis. Gastroenterostomy probably relieves the pain of a gastric or duodenal ulcer by facilitating the emptying of the stomach and so lessening peristalsis. It is also probable that a small amount of jejunal contents regurgitates into the stomach and decreases the acidity of the gastric juice and thereby lessening the peristalsis which is excited by a hyperacid gastric juice. This, however, is not removing the cause and restoring the physiologic conditions, but is merely treating a symptom when the pain is relieved by gastroenterostomy.

The jejunum is physiologically accustomed to alkaline contents. The acidity of the gastric juice is neutralized in the first portion of the duodenum and when the food reaches the jejunum it is always distinctly alkaline. When the acid contents of the stomach are dumped directly into the jejunum, as after a gastroenterostomy, it is natural to expect some reaction on the part of the jejunum against this change from an alkaline to an acid medium. If the urine continued alkaline for several days,

there would probably be a cystitis, and the best method of curing the cystitis is to make the urine acid and so let the bladder contain a medium for which it is physiologically fitted. The pouring out of acid into the jejunum, which is physiologically fitted only for alkaline medium, will naturally produce changes in the jejunum and in all probability a reaction of some kind as a protest against this unphysiologic change. In large clinics jejunal or gastrojejunal ulcers are reported as a late complication in from 2 to 4 per cent. of the total numbers of gastroenterostomy. It seems probable that for every jejunal ulcer there must be many more instances of some reaction to the acid medium on the part of the jejunum, such as chronic hyperæmia, that will be sufficient to produce symptoms, though the symptoms may not be very severe. It is likely that the symptoms caused in this way account for the small percentage of complaint free cases found in carefully traced gastroenterostomy patients. These complaints often do not arise until months or years after the operation, when the jejunum is no longer able to withstand the continued irritation of the acid.

It is well recognized that the most satisfactory results after gastroenterostomy follow stenosis of the pylorus. When there is marked stenosis or extensive infiltration which will probably produce stenosis, the gastroenterostomy opening is eventually the sole exit of the gastric contents. The duodenal contents then retains its maximum alkalinity, which is delivered at the gastroenterostomy opening unimpaired and will readily neutralize the acid of the stomach. In this manner the jejunal mucosa is protected from the acid of the stomach. But when the pylorus remains patent or when it becomes patent after a temporary closure, the alkalinity of the duodenum is impaired by that part of the gastric juice which gains exit through the pylorus, so it cannot fully neutralize the acid that comes through the gastroenterostomy opening; and so the jejunum is not sufficiently protected from the acid. In these cases, then, and obviously in inoperable cancer of the pylorus, gastroenterostomy is a satisfactory operation, but these form a comparatively small number of the cases of gastric surgery. In duodenal or gastric ulcers that can be excised and in a narrow stenosis a pyloroplasty that will return the stomach as nearly to its normal as possible seems more desirable than a gastroenterostomy that continues an unphysiologic condition.

There is one part of the body in which an ulcer in the region of the sphincter has been the object of surgical observation since the earliest time, and the treatment of this condition has been satisfactorily standardized. This is an ulcer or fissure in ano. The analogy between an ulcer in ano and a duodenal or pyloric ulcer of the stomach is very striking. The necessity for paralyzing the sphincter and because it holds an ulcer within its grasp is obvious, for this produces physiologic rest of the tissues. In an ulcer high up in the rectum, paralysis of the sphincter prevents distention of the rectum and back pressure on the ulcer, and causes

a ready emptying of the bowel without the necessity of strong peristalsis. So it is with the tissues in the sphere of influence of the pyloric sphincter after the ulcer is excised. The pyloric sphincter and its adjuvant muscular fibres in the pyloric end of the stomach should be temporarily put out of commission. This, too, is indicated in ulcer in the body of the stomach, so that the stomach can empty its contents readily without having to overcome the physiologic obstruction of the pylorus.

In order to meet these indications, I have been doing a pyloroplasty which is founded upon an effort to remove the pathology by excising the ulcer, to place the tissues at physiologic rest during healing, and, as a late result of the operation to restore them to physiologic normal. This operation is founded upon the principle of making an incision not longer than an inch into the duodenum and of carrying the incision into the stomach not less than twice the distance of the incision in the duodenum. When the ulcer is in the body of the stomach, the incision into the duodenum need be no longer than one-half inch, and into the body of the stomach no longer than an inch. It is best to make the stomach incision first if the ulcer is in the duodenum and then expose and excise the ulcer from within (Fig. 5). Ulcers in the duodenum more than three-fourths of an inch from the pylorus are not fitted for this operation and should be excised transversely and the wound sutured as an ordinary intestinal wound. This has been the practice of Judd of the Mayo Clinic with this type of ulcer, and he has had excellent results. The pyloroplasty wound is closed transversely first by two stay sutures, then by a continuous tanned catgut suture which unites the mucosa, a second row of continuous tanned catgut sutures which merely approximates the peritoneal and muscular coats without attempting to invert them, and then a third row of sutures of fine tanned catgut is placed as a right-angle suture, inverting the other two rows (Figs. 6 and 7). Finally, a tag of gastro-colic or great omentum is brought up over the suture line and fastened in position with a few interrupted sutures of fine tanned catgut.

It is essential in a pyloroplasty to remove a diseased or adherent gall-bladder and to cover raw surfaces carefully, for there is more tugging on duodenal or pyloric adhesions after a pyloroplasty or in a normal stomach than after a gastroenterostomy. The patient should be chiefly on his left side after operation.

This operation differs from the Heineke-Mikulicz in many respects, resembling it only in that in both operations the pylorus is divided and the incision is approximately straight. The Heineke-Mikulicz was conceived on well-known plastic principles to overcome stenosis of the pylorus, but this pyloroplasty is intended to put at physiologic rest the tissues as they are healing. The incision is differently placed from the Heineke-Mikulicz, and rests on the principle that there must always be two parts of the incision in the stomach to one in the duodenum, which gives an excellent view of the pyloric end of the stomach and can be

extended into the stomach almost indefinitely. It requires a rather definite technic to be closed satisfactorily, and when it is closed the ends are in healthy stomach wall and not in a mass of scar tissue, as after the closure of a Heineke-Mikulicz for stenosis. Then the location of the incision and the application of the omentum prevent the pylorus from being drawn up under the liver, as often happens after the Heineke-Mikulicz.

The proof of any therapeutic measures, however, is in the eventual result. I have done twenty-three of these pyloroplasties. Eleven of these cases were reported in the *Journal of the American Medical Association*, August 23, 1919. In the first twelve cases there were three deaths. Two of them were explained very fully in the article mentioned. One was



FIG. 5.—The line shows incision for pyloroplasty which should always be two parts in the stomach to one in the duodenum.

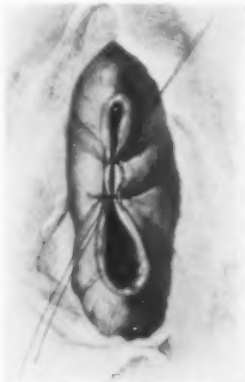


FIG. 6.—Two tractor sutures are placed. The first one unites the extremities of the incision and the second is only one-half inch above the first suture. Originally they were placed too far apart.



FIG. 7.—The mucosa has been united with a continuous lock stitch of tanned or chromic catgut. The second row of sutures is shown in this illustration. It merely approximates the cut edges of the muscular and peritoneal coats. No effort is made to turn in tissue with this second row of sutures as was originally shown. The third row, however, is a right-angle suture of fine tanned catgut, and invaginates the other two rows.

due to a secondary hemorrhage from an ulcer in the body of the stomach twenty-one days after the operation, and was in no way connected with the pyloroplasty. The other death was from a secondary hemorrhage on the eighth day after the operation from too deep division of a cicatricial band in the pylorus. I think both of these deaths could be avoided now. The third death was the twelfth operation and was due to uræmia. In all of these patients a post-mortem examination of the abdominal viscera was made and no one could hold the pyloroplasty for the fatal results. Since that time there have been eleven consecutive cases without a death.

For the first few months after operation, the results from this pyloroplasty do not differ greatly from the results after gastroenterostomy. It is only when the action of the gastric juice on the jejunal mucosa has set up irritation many months after gastroenterostomy that the ultimate clinical results show the advantage of the pyloroplasty over gastroenterostomy.

Since January 1, 1912, I have done fifteen resections of the small

bowel according to the technic described. There were four deaths, all following resection for obstruction. In all four of these cases the patients were in a desperate condition, one death occurring three hours and another six hours after resection. The third fatal case followed five days after the resection, which was done in the presence of suppurative peritonitis. The fourth death was in a patient sixty-eight years of age for whom I had done, under local anæsthetic, a resection of gangrenous bowel due to strangulated hernia. The ligated triangular spaces of the mesentery were not caught with the continuous mattress suture as they should have been. They retracted, and an abscess formed, which, though small, caused obstruction, toxæmia and death. Thirteen of the total number of resections were for obstruction due to bands, volvulus, mesenteric thrombosis, or strangulated hernia. Among those who made a satisfactory recovery are three patients aged, respectively, sixty-seven, sixty-nine, and seventy-three years, in each of whom resection was done under local anæsthetic for gangrenous bowel from strangulated femoral hernia.

During the past twelve years I have done ten resections of the cæcum and ascending colon without a death. In all of these cases the principles of end-to-end union, ligation of the mesentery and its triangular space before opening the bowel, and cleaning the ends of the bowel before suturing, were carried out. The Barber operation was performed in one case. In four cases the valve formation was done. In the last three cases the technic as described with enterostomy and valve formation was fully carried out, and the absence of distention and the smooth convalescence were noticeable in each of these patients.

## SOLID TUMORS OF THE MESENTERY

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SOLID tumors of the mesentery, though frequently described, are of sufficient rarity to warrant individual case reports, particularly when the case presents unusual features. In examining the reported cases there is a striking similarity in certain salient points in the histories. The diagnosis is rarely made, even in cases unaccompanied by obstruction. The mortality in the operated cases is extremely high, and the question always comes up at operation whether to remove the tumor from the mesentery or to do an intestinal resection.

Arising as they do from the connective tissue within the mesenteric leaves, these tumors are invariably of the connective-tissue type of tumor; fibroma, fibro-myoma, lipoma and sarcoma. One case has been reported of a neuro-fibroma. The few reported cases of carcinoma are undoubtedly secondary to a primary carcinoma of the intestinal wall, spreading into the mesentery by continuity of tissue. The primary retroperitoneal sarcomata which grow between and push apart the leaves of the mesentery must be both clinically and pathologically differentiated from the primary mesenteric sarcoma. Pathologically the primary mesenteric sarcomata are nearly always fibro- or spindle-celled, while the primary retroperitoneal sarcomata which secondarily invade the mesentery are, as a rule, small or large round-celled.

The first mesenteric tumor successfully treated by operation, a cyst was reported by Tillaux,<sup>1</sup> in 1880. In an exhaustive study in 1906, Vance<sup>2</sup> collected 27 cases reported in the five previous years. Of these, 7 were sarcomata, 1 carcinoma, and the rest benign tumors of neoplastic origin. In the 27 cases in which operation was done, 11 died, a mortality of 40.7 per cent. Resection of the overlying bowel was done in 13 cases, with a mortality of 46 per cent. From these figures it is evident that intestinal resection only slightly increases the mortality of the operation. An interesting feature in Vance's cases is that of the sarcomata coming to operation, only one survived the operation. Since Vance's article, numerous individual cases have been added to the literature.

Without an exhaustive study of the literature, we have been able to collect about fifteen subsequent cases. A striking feature in all is the almost invariable failure to make a diagnosis, and the entire absence of the X-ray reports.

In those cases which appear with the syndrome of an acute intestinal obstruction, diagnosis is out of the question, as the symptoms of ob-

struction entirely mask the underlying condition. In cases, however, in which the operation is done *a'froid*, the diagnosis should at least be suspected. These tumors have one feature in common, that is their mobility. In nearly all instances, except where it springs from the rectosigmoid junction, the tumor is freely movable and can be pushed from side to side

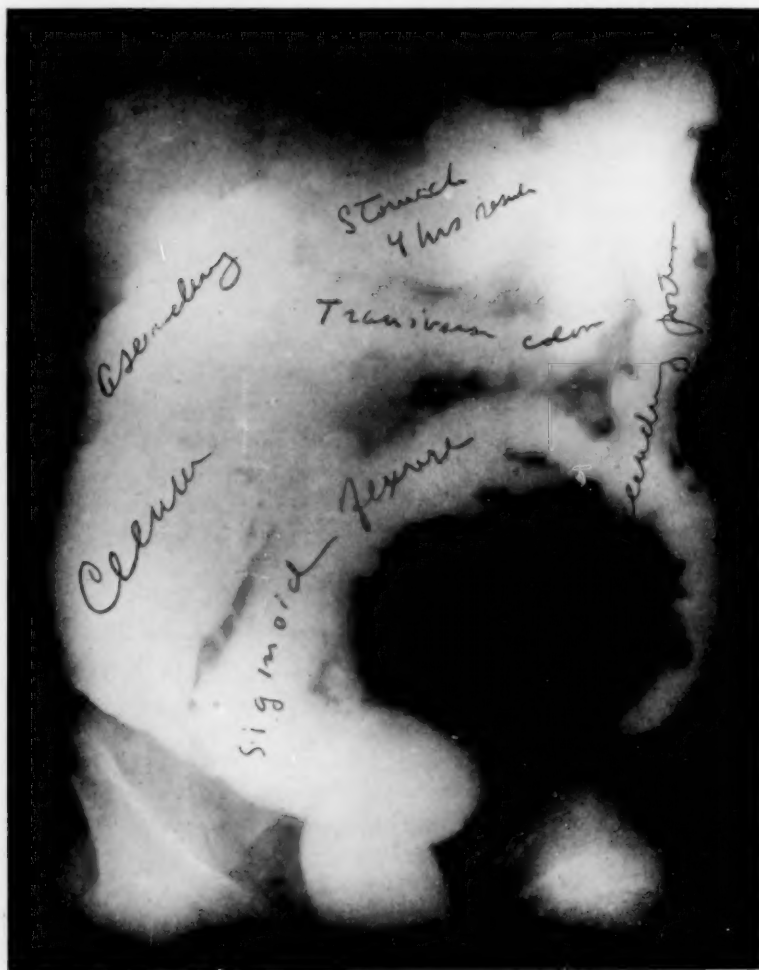


FIG. 1.—Conditions revealed by X-ray in case reported.

in the abdomen; as a rule, painlessly. This mobility they have in common with most ovarian cysts, omental cysts and pedunculated fibroid tumors. The age of incidence is of no significance in the diagnosis, as these cases have been reported at all ages.

Biglow and Forman<sup>3</sup> reported a case in a child of six years. Bilisario,<sup>4</sup> a case of mesenteric cyst in an infant less than a year old. In Bevan's<sup>5</sup> case, in spite of the enormous size of the tumor, the diagnosis before

## SOLID TUMORS OF THE MESENTERY

operation lay between a mesenteric sarcoma and an omental cyst. For self-evident reasons the diagnosis of these cases is far more difficult in women than in men. The X-ray findings of extreme importance, except in tumors springing from the small intestines, since these have neither definite anatomical nor X-ray location. However, the large intestine, both from an anatomic and X-ray standpoint, has a well-defined position, and any gross variations are easily detected, even in the absence of obstruction. For example, a normally filled transverse colon, with a sharp curve deflected upward, combined with a movable tumor in the central abdominal area, would certainly suggest a tumor of the transverse mesocolon. In the same way, a movable tumor in the lower left abdominal quadrant, combined with a radiographic picture of unusual sigmoid looping, would undoubtedly suggest a tumor of the mesosigmoid.

An important question which can only be settled during the operation is that of intestinal resection. Though resection undoubtedly slightly increases the operative mortality, it must be done if there is any doubt as to the viability of the bowel. In Biglow's case the failure to resect was proven by post-mortem to be the cause of the fatality, as there was a necrosis of the intestine following an interference with its nutrition. These tumors are usually so closely connected with the blood supply of the overlying intestine that there is great danger in interfering with the viability of the bowel through the removal of the tumor. As in strangulated hernia, if in doubt, resect.

Male, aged seventy-three years. After a marked dietary indiscretion, had a good deal of epigastric distress. While examining the abdomen, a large tumor mass was discovered in the lower left quadrant. This mass was about the size of an orange, and did not seem to be movable. It was smooth in outline and exceedingly hard. The patient, himself, was unaware of its presence. The mass was not tender to pressure and the intestinal coils could be slipped over it. It was not adherent to the abdominal wall. The inguinal glands were enlarged and hard on the left side. They were palpable but smaller on the right side. The prostate was hard, firm, perfectly smooth, and considerably enlarged. The seminal vesicles were normal. No definite connection could be traced between the abdominal mass and the genito-urinary tract. The physical examination otherwise showed the heart to be normal for a man of the patient's years. The lungs were normal.

X-ray examination (Fig. 1) had the following results:

*Thoracic and Gastro-Intestinal Examination:*

*Lungs.*—Hilum shows shadows increased. Bronchial tree prominent. Parenchyma transparent. Diaphragmatic excursions not impaired.

*Heart and Aorta.*—In normal position and of normal size. Thoracic aorta dilated.

*Esophagus.*—In normal position and not obstructed.

*Stomach.*—Size medium. Position, cardiac to left, middle portion in

front, pyloric end to right of spinal column. Greater curvature about two inches above crest of ilium. Hypertonic, steer-horn in shape, no adhesions, no filling defects, no tenderness. Pylorus dilated. Pyloric sphincter spasmodic. Peristalsis sluggish.

*Duodenum.*—Visualized after considerable manipulation. Duodenal bulb triangular in shape and regular in outline.

*Gall-bladder.*—Not visualized.

*Liver and Spleen.*—In normal position and not enlarged.

*Four Hours Later.*—Considerable residue in the stomach.

*Barium Enema.*—No obstruction encountered along the course of entire colon. The sigmoid flexure is elevated and displaced to the right by a mass which is extrinsic. Cæcum is redundant. No tenderness.

*Urine Examination.*—A.M.—Albumen and sugar negative. Microscopical: Uric acid and large quantities of oxalate of lime. P.M.—Albumen and sugar negative. Microscopical: Granular and hyaline casts. Large round epithelial cells in very considerable numbers. Red blood-cells. White blood-cells. Oxalate of lime.

*Blood Examination.*—Red blood-cells, 5,200,000. White blood-cells, 9600. Hæmoglobin, 100 per cent. Differential: Polys., 143-71.05 per cent. Large monos., 17-8.05 per cent. Small monos., 35-17.05 per cent. Eosinophiles, 3-2.05 per cent. Transitionals, 2-1 per cent. Strained specimen shows characteristics of mild degree of secondary anæmia.

*Diagnosis.*—Mesenteric tumor, probably malignant, lower left quadrant.

In spite of the lack of characteristic mobility, the diagnosis was made by exclusion, the deformity of the sigmoid loop pointing conclusively to the diagnosis. The reason for the lack of mobility here was the fact that the lower part of the tumor was locked in the pelvis. Operation, Jewish Hospital, January 17, 1920; gas oxygen anæsthesia; tumor the size of fetal head was found in the mesosigmoid, just above the rectosigmoid junction. The sigmoid was flattened over the tumor like a ribbon. The left leaves of the mesentery were split and the tumor easily enucleated. This, however, seemed to interfere with the viability of the sigmoid loop, which had been over the tumor. Twelve inches of the sigmoid were resected, and an end-to-end anastomosis made. This anastomosis was technically difficult, as it was made at the rectosigmoid juncture. The anastomosis was covered with a free omental graft. Two cigarette drains were left at the site of the anastomosis. The rest of the wound was closed. Seven days after operation the bowels were moved with an enema. Four days later a small fecal fistula developed, which, however, closed automatically. February 4, 1920, further convalescence was uneventful. *Pathological report:* Fibro-sarcoma.

NOTE.—Since writing the above, the patient presents symptoms of a recurrence.

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## STAVE FRACTURE OF THE FIRST METATARSAL BONE

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STAVE fractures of the metatarsal bones are rare. No mention of this type of fracture is made by Cotton, Scudder, Stimson, Moorehead, DaCosta or Keene. A stave of the metacarpal bone, on the other hand, is fairly common, that of the thumb being called Bennett's fracture. A stave of the thumb usually results from violent force applied to the distal end of the extended thumb. It is a fracture of the proximal end of the metacarpal, oblique or longitudinal and into the joint with the trapezium. There is, usually, a backward dislocation of the first metacarpal bone.

The case to be described is a stave at the base of the first metatarsal bone, and into the articulation with the internal cuneiform.

J. H. G., colored, aged thirty-five years, employed as a laborer in a warehouse, pulling a four-wheeled truck. When loaded, this truck requires two men to move it, one in the rear pushing it and one in front pulling by means of a handle. In going down a slight decline in the warehouse, one of the wheels of the truck struck the back of the elevated heel of the right foot. The ankle-joint was severely wrenched. He had to stop work immediately because of pain in the ankle-joint and foot. The patient was seen about a half hour after the accident and the following was noted: The injured foot showed a third degree of pes planus. The opposite foot, examined for comparison, also showed this deformity. The astragalo-scaphoid joint of the affected foot bulged inward and downward. The inner border of foot was markedly convex. The ankle-joint, on its anterior and lateral aspect, was swollen. The movements of the foot were painful, especially plantar flexion, abduction and eversion. Palpation revealed an area of pain and tenderness on the inner border of the base of the first metatarsal bone and at the insertion of the tibialis-anticus tendon. There was considerable pain and tenderness to pressure beneath the internal malleolus, indicating a sprain of the internal lateral ligament. No crepitus was elicited. The X-ray showed an oblique fracture of the base of the first metatarsal.

The mechanism in the production of this fracture differs from that of the thumb, in that the violence is transmitted through a series of bones (the mid-tarsum), finally spending its force upon the principal pillar of the fore-foot, the strong first metatarsal. The fracture produced is therefore due to indirect force.

When the impact of the violence is received upon the back of the heel, the foot is in plantar flexion and weight is momentarily borne upon

the anterior metatarsal arch and toes. There is a sprain of the capsular ligament of the ankle-joint at its attachment to the anterior margin of the lower anterior border of the tibia and perhaps also the margin of attachment to the astragalus. There is also some strain put upon the lateral ligaments. The violence is diffused forward, downward, inward and upward. There is an anterior subluxation of the astragalus. The



FIG. 1.—Stave fracture of base of first metatarsal bone.

head of this bone is forced downward and inward upon the scaphoid, carrying the latter with it. The strong inferior calcaneo-scaphoid ligament being relaxed in this case, owing to the deformity, does not resist the strain. The internal cuneiform bone receives this violence, and it in turn is jammed against the base of the first metatarsal bone. The latter, being the last bone in the line of force, does not move anteriorly because it rests on the ground. Dislocation backward does not occur; and inward displacement is restricted by the peroneus-longus muscle which is inserted into the inferior surface of the base. The first metatarsal bone, caught between these forces, will fracture at the base.

An accurate diagnosis of these cases cannot be made unless the X-ray is employed. The symptomatology of this type of injury is rather severe because of the extensive injury to the

capsule and the lateral ligaments of the ankle-joint.

The treatment of a stave fracture of the first metatarsal is to supinate and adduct the foot at right angles to the leg and immediate immobilization in this position by means of plaster of Paris for about two weeks, followed later on by baking, massage, passive and active movements. Weight may be borne about the end of a month.

## TUMORS IN SOUTH CHINA

BASED UPON RECORDS OF OPERATIONS PERFORMED IN THE CANTON HOSPITAL  
DURING THE TEN YEARS 1910 TO 1919.

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CANTON, the capital city of Kwongtung Province and the largest city in China, with a population of more than one and a half millions of people, is situated upon the Pearl River, ninety miles from the sea, upon the northern border of a great delta, in Lat. 23 degrees 7 min. North, and Long. 113 degrees, 14 min. East. It is the port for several of the neighboring provinces as well, with a population of fifty millions.

The climate is subtropical. During the past ten years the maximum summer temperature was  $101^{\circ}$ , the mean  $85.53^{\circ}$  and minimum  $65^{\circ}$ , with humidity averaging about 99. The minimum temperature in winter was  $34^{\circ}$ , the mean  $58.65^{\circ}$  and maximum  $83^{\circ}$ . Snow is only seen on the mountain tops in the northern part of the province. Frost and hail are very rarely seen. During the months of October to February, inclusive, but little rain falls, the average being 1.45 inches per month. During the spring months, the rainy season, the average rainfall was 4.76 inches per month. The sky is overcast during most of this period. The weather during the summer months is usually clear and dry, though the humidity may be excessive, especially preceding heavy tropical thunderstorms and destructive typhoons, which are accompanied with deluges of rain, the average per month being 10.29 inches.

The majority of the people are agriculturists, living in villages, for mutual protection. Wet cultivation of rice is practised in the delta. The people are poor, but self-respecting. Their diet is limited in variety, and frequently quantity, as a result of floods. Rice, greens, fish, and tea are the staples. Human manure is used as a fertilizer, and as a consequence a very large proportion of the population is infected with intestinal parasites. Living conditions are very unsanitary.

The knowledge of scientific medicine in China had been in a state of arrested development until its introduction by missionary physicians in 1835 when the Canton Hospital was founded by Dr. Peter Parker, a Yale graduate, who is said to have opened China at the point of the lancet.

Owing to ancestral worship, the Chinese do not approve of mutilation of the human body, and thus ignorance of human anatomy is profound. The chief reliance for diagnosis has been the fæces and pulse of the patient, and medicinal remedies are secured from the animal, vegetable, and mineral world. There are internists and externists. The foreign surgeon is

called an externist, the physician an internist. Such conditions as tumors, abscesses, and ulcers, come to the surgeon for treatment; also fractures, dislocations, and gangrene. The only procedures employed by the Chinese externist are counter-irritation, cauterization, pinching the skin and tissues, acupuncture, and the application of plasters. Although during the past eighty-five years more than two million Chinese have been treated at the Canton Hospital and its dispensaries, it is certain that only the minority of the people of Canton city avail themselves of the services of foreign practitioners, and most of these for conditions requiring surgical treatment. The women do not readily submit to examination by men, and thus only about 35 per cent. of the patients treated in the Canton Hospital are women.

During the past ten years 120,000 dispensary and 19,524 inpatients were treated in the Canton Hospital; 13,761 operations were performed upon inpatients. Ninety-eight per cent. of the patients were Chinese, 80 per cent. were residents in this province and 20 per cent. in fifteen other provinces; 35 per cent. of the inpatients came from the immediate neighborhood of Canton, and 65 per cent. from districts throughout the two provinces with a population of forty millions. About 30 per cent. of the inpatients are farmers, 17 per cent. soldiers, 13 per cent. housewives, 12 per cent. merchants, 10 per cent. laborers, 8 per cent. students, and the other 10 per cent. miscellaneous occupations.

Seventy-five per cent. of the inpatients treated in the Canton Hospital are from the laboring classes. The same percentage of cases are of a chronic nature, or seen at a late stage of the disease. The patients usually try out the native physicians first, who, as a rule, aggravate the condition by their treatment, and relieve the patients of their substance. They therefore come to the missionary hospital in poor condition, anæmic from intestinal parasites, and in a state of malnutrition. As pain is the chief factor in causing the patients to come to the hospital, the disease is frequently inoperable.

Large tumors of many varieties and different tissues are observed. Heredity does not seem to be a factor, nor does occupation. Coolies carry their loads by means of a pole laid across the shoulder, and although the subjacent tissues are thickened, malignancy but rarely develops. The laborers work early and late, exposed to sun, rain, heat, and cold. Ulcers of the legs are common, 542 having been treated during this period, but malignancy is a sequel that is but rarely seen. Syphilis is not common among the farming class. The Chinese marry young. The majority of the tumors seen are external.

The following data are based upon the records of the 13,761 operative procedures performed in the Canton Hospital during the past ten years, the greater number of which I was responsible for. My thanks are due to other members of the staff for the use of their records.

One thousand five hundred and sixty tumors were excised (12 per

## TUMORS IN SOUTH CHINA

cent. of the total operations); 1090, or 70 per cent., were benign, and 470, or 30 per cent., malignant. There were 290 carcinomas and 180 sarcomas; 60 were epitheliomata. Malignant growths seem to be about equally prevalent in males and females. Males are more inclined to sarcoma; the average age was forty years. The average age of those treated for carcinoma was forty-four years. There were 105 papillomata, 134 sebaceous cysts, 69 lipomata, 54 fibromata, 51 keloids, and 9 myomata.

To the Chinese any abnormal swelling is a tumor. Among such conditions dealt with were 943 abscesses, 567 cases of osteomyelitis, 268 cases of lymphadenitis, 130 hydroceles, 55 herniæ, 33 aneurisms, and 30 carbuncles.

*Bones and Joints.*—Twenty-six cases of osteosarcoma of the femur, tibia, fibula, humerus, radius, inferior maxilla, superior maxilla, and pelvis, requiring excision or amputation. There were 9 osteomata, 6 enchondromata, and 4 chronic enlargements of the os calcis. Many cases of osteosclerosis, and a few of acromegaly, were seen. Case No. 14,569, male, aged thirty-five years, with symptoms dating for two years previous to admission, had myeloid sarcoma of the right knee, which was  $32\frac{1}{2}$  inches in circumference, the normal one being 12 inches. Case No. 19,344, a male, farmer, aged forty-nine years, with sarcoma of the inferior maxilla, large, hard, immovable, and cervical adenitis, growing for a year and a half. The common carotid artery was ligated, the half of the inferior maxilla resected and glands excised.

*Circulatory System.*—Thirteen angiomata were treated and one perithelioma of the carotid body excised. Case No. 191,683, male, aged fifty-six years, charcoal merchant, noticed a small tumor on his neck twenty years previous which commenced to enlarge rapidly two years ago. The tumor was the size of an egg, upper part hard, lower part firm, movable laterally (slightly) with lateral pulsation, no bruit. The tumor was found to be situated at the carotid fork, perforated by the carotid arteries, which were ligated, and the tumor dissected out. The larger arteries were ligated 132 times in 32 per cent. of the cases, the external carotid with no fatality; and in 28 per cent. of the cases the common carotid with two deaths, one upon the operating table and one three days later.

*Digestive System.*—Mouth, jaw, etc., 8 ranulas, 15 tumors, 8 cancers of the lip and 4 of the tongue; males, average age fifty-nine years. There was one sessile fibrosarcoma of the posterior pharynx of two years' duration, Case 14,867, male, farmer, aged twenty-seven years, had nostrils also filled with polypi, which were first snared. A preliminary tracheotomy was performed. The soft palate was split, and the tumor excised. Because of the hemorrhage it was necessary to pack the pharynx for twenty-four hours.

*Abdomen and Wall.*—Thirty-nine exploratory laparotomies were performed in which the tumors were found to be inoperable. There were 5 splenectomies, and 5 carcinoma of the stomach and 6 of the liver. The average age for the males was forty-one years and for

the females forty-five years. Case No. 141,438, a female, a farmer's wife aged twenty-nine years, had a cyst of the mesentery 5 inches in diameter which she had first noticed six months previous. Three cases of tubercular mesenteric glands were operated upon and eight cancers of the rectum, the average age being fifty years. There were several rectal polypi.

*Genito-urinary System* (170 buboes, average age twenty-eight years).—There were thirty-six cases of cancer of the penis, usually with a history of syphilis or gonorrhoea. The cases were advanced, ulcerated, with pain, hemorrhage, and inguinal adenitis. They were farmers, merchants, and laborers in this order of frequency. The ages ranged from twenty-nine to fifty-seven, average forty years. The duration of disease was given as from two months to three years, average one and one-half years. There were 11 orchidectomies for tumor, 6 malignant growths of the bladder, 6 hypertrophied prostates and 1 of malignancy, 6 cases of elephantiasis of the penis and scrotum, 2 varicoceles, and a few polyps and cysts. Case No. 191,959, male, aged sixty-five years, had complete retention for four days, greatly hypertrophied prostate, 155 small vesical calculi (total weight 14 grams), inguinal hernia, and double hydrocele. Case No. 161,380, male aged sixty-five years, farmer, had complete retention of urine for two days. He had been repeatedly catheterized outside and in addition to stricture had many false passages. He had in addition hypertrophied prostate, 8 small vesical calculi, double inguinal hernia, and hemorrhoids.

*Lymphatic System, Ductless Glands, Etc.*—Five parenchymatous and 1 exophthalmic goitres were operated upon. Four splenectomies were performed, and one splenic artery was ligated for splenomegaly. This is a common condition, but most of the cases are treated in the medical service. The disease is commoner in males, and the average age of those admitted to the hospital is thirty-one years. Several cases of malignancy of the pancreas were seen.

Seventy cases of carcinoma of the breast were operated upon, the radical operation being performed. Eighty-five per cent. were public ward patients, the ages ranging from twenty-one to seventy-four years, the average being forty-two; 95 per cent. were married women. The occupations were in order of frequency, farmers, housewives, laborers, and seamstresses. The left breast was affected in 64 per cent. and the right in 36 per cent. The duration of disease given was from four months to thirty years, the average being two and one-quarter years. In the case of the tumor of thirty years, the pain and adenitis had only been present for six months. The majority of the cases had axillary adenitis. In many cases Chinese medicine having been applied, the superficial tissues had broken down. Several recurrences were noted. Owing to conditions existing in China, it is very difficult to obtain end-results. Many inoperable cases are seen (Fig. 2).

Twenty-seven adenomata of the breast were removed. The ages of the patients ranged from thirty to seventy, the average being



FIG. 1 (Case 14-1560).—Osteosarcoma of femur of twenty years' duration. Disarticulation at hip joint.



FIG. 2.—Patient with cancer of the breast.



FIG. 3.—Fibrosarcoma of the upper eyelid removed from patient 20-864 in the Canton Hospital.

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thirty-seven years. The average duration of disease was three years. One patient stated that her habit of scolding was the cause of the tumor.

Twelve mixed tumors of the parotid gland were excised. These tumors are usually large when seen.

Cervical adenitis, tubercular, 268 cases, 60 per cent. males, 40 per cent. females; aged six months to fifty-six years, average male twenty-two, female twenty; married, 35 per cent.; single, 65 per cent.; duration of disease twenty days to three years, average one year; 60 per cent. both sides of neck affected, 40 per cent. left side only; occupations in order of frequency, farmers, soldiers, merchants, students, and silkworkers. Many cases required ligation of the internal jugular vein in the block dissection. Many of the operations are rendered more difficult because of preliminary treatment by the Chinese quacks who apply strong plasters and counter-irritation producing dermatitis, adhesions, ulceration, scars, and keloids.

Seventy-one patients with lymphosarcoma were operated upon, 83 per cent. males and 17 per cent. females, 97 per cent. were married. The ages ranged from twenty-two to fifty-six years, average forty; 44 per cent. were double, 28 per cent. left, and 28 per cent. right side of the neck. The duration was two months to eight years, the average being one and one-half years. Occupations, 25 per cent. farmers, 12 per cent. merchants, the balance miscellaneous. In inoperable cases the supplying artery is frequently ligated, either the external carotid, if possible (without a fatality), or the common (with only two deaths). Frequently, as a consequence, the tumor becomes operable after a delay of a week or ten days. The hæmoglobin averaged 70 per cent. The chief symptoms were headache, pain in the neck and head, difficulty in swallowing, and loss of weight. Some had epistaxis, tinnitus, cough, and expectoration. Probably the majority of patients admitted to the hospital are affected with intestinal parasites.

Thirty-one cases of elephantiasis were dealt with, one of the face, one of the labia, and the rest equally divided between the leg and penis and scrotum. The ages were from fifteen to fifty-four years, average thirty-three; 75 per cent. were males. There were the same number of single as married. The duration of disease was from two and one-half to ten years, average five years. Occupation, farmers, 65 per cent.

*Infections.*—In addition to the bacteria and parasites already mentioned as the cause of abnormal swellings may be mentioned 21 cases of abscess of the liver due to the amœba; 30 carbuncles; psoas abscess is quite common, the average age of the patients with this condition being twenty-four years.

*Nervous System.*—Five neuromata were excised, including one tumor of the spinal cord.

*Gynecology.*—There were 209 tumors of the female generative organs. Ovarian cystadenomata, 140; 82 per cent. were public ward patients; 4 died; 80 per cent. were married, and 20 per cent. single;

65 per cent. had borne children and 35 per cent. had not been pregnant. The ages ranged from twenty to fifty-two years, the average was thirty-one years upon admission to the hospital. The duration of disease was from three months to twenty years (as stated by patient), the average three years. The greater number were left-sided cysts. The occupations in order of frequency were farmers, silkworkers, and seamstresses. Hæmoglobin average, 74 per cent. The average abdominal girth was 47 inches, and weight of the tumors 40 pounds. Fifteen years was the average age at which menstruation commenced. One tumor weighed 116½ pounds, and the patient 79 pounds after the tumor had been removed. Among the complications met with were splenomegaly, multiple cysts, fibroid of uterus, tubercular peritonitis, salpingitis, insanity, ascites, pancreatitis, and retroverted uterus. There were unilocular, multilocular, and solid tumors in this order of frequency. Adhesions to the peritoneum, omentum, small bowel, large intestine (requiring colocolostomy), appendix, bladder, uterus, liver, etc., required to be separated.

There were 6 parovarian cysts, 4 dermoids of the ovary, 1 papiloma of the broad ligament, and 1 cancer of the broad ligament. Twenty-five patients with carcinoma of the uterus were operated upon. The ages were from thirty-eight to fifty years, the average being forty-five. All of the patients were married. They were housewives or farmers. The duration of disease was from five months to two years, average seven months.

There were 21 uterine fibroids. The largest weighed 20 pounds, the patient's abdominal girth being 35 inches. The ovaries were cystic also. The ages were from thirty-two to fifty years, the average being thirty-seven. The duration of disease was from three to twelve years, average six years. There were 5 cysts, 2 adenomata, and 3 cancers of the vulva, also 3 uterine polypi. In Case No. 161,374 the dermoid cyst contained masses of hair, eyelashes and three teeth.

*Ophthalmology.*—Forty-four chalazions, 4 gliomata, 4 mucocoeles, 3 cysts, and 10 miscellaneous tumors were excised (Fig. 3).

*Otology, Rhinology, and Laryngology.*—Ninety-three tonsils, 83 nasal polypi, 50 adenoids, 31 turbinectomies, 20 aural polypi, and 1 fibrosarcoma of the posterior nares were removed.

**PSEUDO-POLYCYTHEMIA: EXTRAORDINARY BLOOD-CHANGES  
IN A PATIENT WITH RENAL CALCULUS**

**BY LEON HERMAN, M.D.**

**AND**

**B. B. VINCENT LYON, M.D.  
OF PHILADELPHIA, PA.**

TRUE polycythemia is a well-established clinical entity with which our case has little, if anything, in common. We submit this report, not with the idea of adding to the data, already quite extensive, on the true polycythemic disease, but to place on record clinical and cytological evidence that remarkable functional disturbances sometimes occur in the hæmopoetic tissues in the absence of demonstrable organic changes in these tissues, in so far as the clinical demonstration of the latter is concerned.

We have received the following letter from Dr. Alfred Stengel, professor of medicine in the University of Pennsylvania, whose interest in the case we greatly appreciate: "Many thanks for the report of your remarkable case of polycythemia. I know of nothing in the literature that bears upon a polycythemia in connection with a kidney condition and disappearing when the kidney was removed; nor do I know of anything like the sudden flood of white-cells, mainly polymorphonuclears, such as occurred after the operation. The case was observed carefully, and although you have no explanation for the phenomena, its remarkable features warrant publication of the facts."

Mr. J. R., aged forty-nine years, a native of Spain and a chemist by occupation, presented himself for examination in 1914, when the following history was obtained. The patient had been a resident of Cuba from 1889 to 1906, and had served with the Spanish army during the Spanish-American War. During his active service with the army, he had contracted malaria which was insufficiently treated so that it lasted for many months. Two years prior to the malarial attack, he had suffered a severe burn with boiling oil. From this he recovered very promptly, and with the exception of certain accidental injuries and the condition for which he now consults us, he has been quite healthy. The first indication of kidney disease appeared in 1897, when he had what both he and his physician thought at the time was an attack of appendicitis. For several years prior to this he had been aware of the presence of an abnormality of the blood. Thus while assisting Dr. Domingo Madan of Matanzas, Cuba, in 1893, with the microscopical part of his researches on malaria, a blood-count was made "merely as a matter of curiosity," and it was found that his blood contained an unusually high proportion of red cells, the exact number of which he does not recall. He was in perfect health at the time and no attention was paid to the polycythemia.

There is little of further interest in the history until 1900 when he began to notice dull pains in the region of the appendix. About three weeks after the onset of these pains, he experienced his first attack of renal colic. This was soon followed by several very severe attacks after which he passed two small jagged stones. The pain was localized to the right side of the abdomen in each attack.

Following the passage of the stones he was without symptoms until 1914, when he presented himself complaining of indefinite pain in the upper right abdomen. After a thorough study including X-ray and cystoscopic examinations, the diagnosis of renal calculus was made and an operation was advised. The latter was postponed and the patient remained comparatively well until February, 1919, when after a violent attack of pain a third stone was passed. Ten days later he was again cystoscoped and the following facts were ascertained: Bladder mucosa normal except in the region of the right ureteral orifice: the latter is dilated and the surrounding mucosa is congested, contused, and oedematous. Urine from the right kidney is cloudy and contains a considerable amount of pus; that from the left kidney is normal. The urine from the right kidney was found to contain the colon bacillus in pure culture. The ureteral catheter meets with an obstruction in the region of the right ureteropelvic junction, but the flow of urine is apparently not interfered with. Indigo-carmin injected intravenously is eliminated from the left kidney in three minutes while only a faint trace of the dye is recovered from the right kidney during a half-hour period, the appearance time being eleven and one-half minutes.

Several days later a differential phthalein test gave the following results: The appearance time of the drug on the right side is seventeen minutes and only a faint trace of the dye is recovered: the excretion from the left kidney began in four minutes, and twenty-two and one-half per cent. is recovered during the first fifteen minutes of excretion.

The X-ray picture shows three shadows in the right kidney region, one large one, about the size of a plum, in the region of the pelvis, and two split-pea-sized ones in the location of the lower pole of the kidney.

The diagnosis of calculus with infected kidney was evident and the patient was sent to the Methodist Episcopal Hospital on March 10, 1919, for operation.

On the day following the patient's admission to the hospital, the resident physician reported a most remarkable condition of the blood; the erythrocytes were said to be 11,496,000 per cm., the hæmoglobin 115 to 120 per cent., the clotting time seven and one-half minutes, and the leucocytes 11,600 per cm.

Suspecting that some error in technic had been made, further examinations of the blood were made; this was done by taking specimens from both the finger-tip and the basilic vein on several occasions; the findings were, with very slight differences, the same as

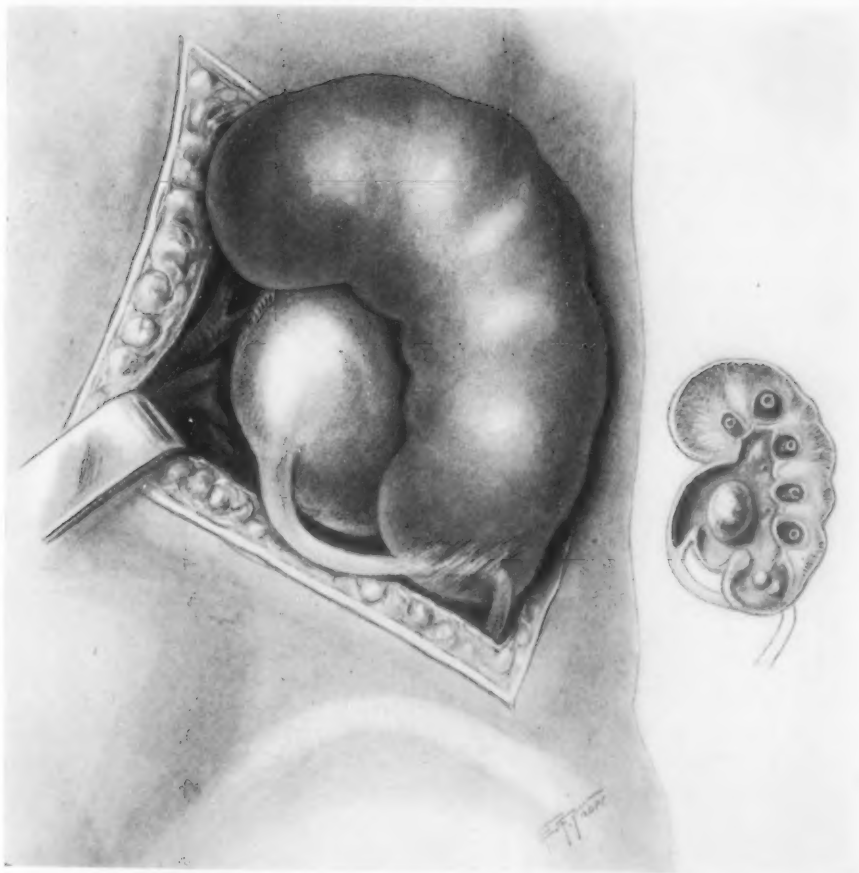


FIG. 1.—Hydronephrosis with calculi in a patient with pseudo-polycythemia. Note the perirenal adhesions attaching the ureter to the posterior surface of the lower pole of the kidney. The cause of these adhesions is found in a dilated and inflamed lower calyx which contains two small stones. The renal cortex at this point is very thin. The true pelvis is dilated and contains a larger stone.



those reported at the first examination. The later examinations were made by Dr. Russell Richardson.

We had considered the patient to be in excellent general physical condition, but in view of the unusual condition of the blood, he was again examined with the greatest care and we could find no evidence of cyanosis, enlargement of the spleen, or other signs of true polycythemia. We then searched for but failed to find any data concerning the significance of this type of polycythemia in kidney surgery, and after explaining the condition to the patient who insisted that the increased number of red cells would hasten the healing of the operative wound, we proceeded to remove the right kidney.

The kidney was exposed through an oblique incision under ether anaesthesia. It was found to be slightly ptosed and moderately enlarged. The extrarenal portion of the pelvis was dilated to about the size of a hen's egg and contained a rounded, plum-sized stone (Fig. 1). The organ was delivered after freeing a very few adhesions and the ureter was exposed several inches below the lower pole of the kidney and divided between clamps. On tracing the proximal segment of the ureter upward, it was found that the tube was densely adherent to the posterior surface of the lower pole of the kidney. Subsequent examination of the removed kidney showed that the ureter had been caught up in a mass of perirenal adhesions and had been drawn to the surface of the kidney to which it was adherent, thus producing a marked kinking of the tube.

The cause of the perirenal inflammation was found in a dilated and infected lower calyx which contained the two small stones shown in the X-ray plate. The cortex of the kidney at this point had become greatly thinned and transformed, for the most part, into fibrous tissue. The lumen of the ureter was somewhat constricted where it was adherent to the renal surface, but the obstruction found on attempting to pass the ureteral catheter was evidently due to kinking of the tube rather than to actual obliteration of its lumen.

Microscopic studies of the renal cortex showed more or less cloudy swelling and necrosis of the tubules. The majority of the glomeruli showed considerable congestion together with cellular proliferation, and some slight infiltration with small round-cells. There was very little increase in connective tissue throughout the organ; in fact, the degree of kidney destruction did not seem sufficient to explain the almost complete lack of function as measured by the functional tests. Loose connective tissue containing irregular bits of muscle-fibre were the characteristic features of sections taken from the upper ureter and dilated pelvis. A moderate infiltration with small round-cells was demonstrable throughout the specimen. There is evidently nothing peculiar in the condition of the kidney that could be associated etiologically with the polycythemic state of the blood.

Three days after the operation it was found that the hæmoglobin had become reduced to 108 per cent., together with a remarkable decrease of the red cells to 5,504,000; the leucocytes were 11,200.

The convalescence was proceeding without incident and we were astonished to find on March 27th, thirteen days after operation, that the blood contained the remarkable number of 260,000 leucocytes per cm. Doctor Richardson reported on the following day that the hæmoglobin was 90 per cent., the erythrocytes 4,480,000, and the leucocytes 242,000 per cm. The differential leucocyte count was as follows: Polymorphonuclears, 74 per cent.; small mononuclears, 13 per cent.; large lymphocytes, 4 per cent.; transitionals, 5 per cent.; acidophiles, 4 per cent.; and basophiles, 1 per cent.

The leucocyte count gradually diminished but with a relative increase in the number of polymorphonuclears.

The patient's condition was at all times excellent and the convalescence was entirely without incident. The highest temperature recorded was 99 degrees on the day of operation, and after this it never rose above 98. The systolic blood-pressure fell from 150 before operation to 126 several days after operation: the diastolic pressure fell from 90 to 86.

It was impossible to keep the patient quiet and against our advice he sat up in bed almost from the first and was sitting up in a chair eight days after operation. At this time he insisted upon going home, but this we would not permit.

On March 31st the blood examination showed 88 per cent. of hæmoglobin, 4,360,000 red cells, 22,800 white cells, and a differential leucocyte count as follows: Polymorphonuclears, 81 per cent.; lymphocytes, 16 per cent.; transitionals, 2 per cent.; and acidophiles, 1 per cent.

The patient was discharged from the hospital on April 1st and returned to his work a week later and has since remained well. One year after the operation Doctor Richardson examined the blood and found it to be normal. At no time during the course of these examinations were there any abnormalities in the size or shape of the red cells noted.

## PERTROCHANTERIC FRACTURE OF THE FEMUR

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ACCORDING to Stimson ("A Practical Treatise on Fractures and Dislocations," Lea & Febiger, 1917, 394), this class (*i.e.*, Fractura Pertrochanterica, Kocher) may be defined as composed of those cases in which the line of fracture begins at or near the lower part of the junction of the neck and shaft and passes through or close below the great trochanter, dividing the bone into two parts, of which the upper is formed by the head, neck, and upper part of the trochanter. The line of fracture may be oblique from within, outward and upward, or from behind upward and forward. Such a case was encountered in the service of Professor G. P. Muller, at the Polyclinic Hospital.

This patient (Case No. 2508), a female, aged sixty-five years, was admitted on February 22, 1920, complaining of pain in the right hip and disability on flexion of thigh on abdomen. She stated that she fell on an icy pavement and was unable to get up. *She distinctly remembered falling backward.* She was immediately brought to the hospital.

Physical examination revealed tenderness along upper third of right thigh, most marked near neck. There was no gross deformity. There was some ecchymosis. The limb was so painful that no attempts to elicit crepitus were made. Pending X-ray examination the limb was put up in Buck's traction apparatus.

The skiagram (Fig. 1) revealed the plane of fracture oblique from within outward and upward, beginning several centimetres below the base of the great trochanter, at which point the separation is most marked in the picture.

The plane of fracture in this case somewhat resembles that in Kocher's first case, which is figured by Stimson (*loc. cit.*, Fig. 273, page 395) and corresponds to Stimson's description of his own case, in which the line of fracture was very long and oblique, extending from the top of the trochanter downward and inward.

The treatment in this case was based upon the location of the fracture, the absence of shortening and the presence of but trifling deformity. A plaster-of-Paris spica was applied, beginning at the toes and extending to the costal border. A skiagram taken on April 20th—two months after the injury—showed good alignment and good approximation. The patient was discharged, cured, on May 20, 1920—three months after the injury. At this time the fracture was soundly healed, as could have been forecast by a study of the skiagram, which shows broad surfaces of, for the most part, cancellous bone, with the promise of ample callus.

It was Kocher who first applied the term "pertrochanteric fracture" to this injury, which Stimson classifies under the heading "fractures through

the great trochanter and neck." The best and the most typical example of this fracture is the specimen in the U. S. Army Medical Museum, which is also figured by Stimson (*loc. cit.*, Figs. 275 and 276, page 396). That the plane of the fracture may vary from type, however, is understood by reference to the causative mechanism, which seems to be a cross-breaking strain acting upon the trochanteric region of the femur. In a recent paper on this fracture Wilensky (*Surg., Gynec. and Obstet.*, March, 1920, page 244) states that in all the reported cases the injury followed a fall, and that in all, except one case, the fall was directed backward. "It seems most probable that the injury results from a play of force in which an extraordinary overextension of the trunk at the hip-joint occurs in the dorsal direction with, and upon, the lower limb as a relatively fixed pivot; an enormous strain is transmitted through the unyielding Y ligament which, while incidentally aiding the muscles very powerfully in fixing the upper end of the bone, at the same time determines a line of greatest weakness and least resistance in the bone. In attempting to recover the balance the long flexor muscles of the thigh are very strongly contracted and a powerful stress is exerted across the length of the femur which has the tendency to bow the femur in a forward direction. A sufficient continuation of the indicated stress and strain results in a solution of continuity, and the latter must necessarily take place at the line of least resistance, determined by the Y ligament, which corresponds with the lowermost line of attachment of its fibres a little below the junction of the neck and shaft of the bone."

That this mechanism was effective is strongly suggested by the skiagram in my case (Fig. 1); my patient, too, fell over backward. The fracture, after all, is but a tear- or sprain-fracture on a large scale; indeed, in its mechanism, it reminds one of fracture of the patella due to indirect violence.

Wilensky was much impressed with the rapidity with which his fracture united and with the relatively large amount of callus which formed, and states that all these types have the valuable characteristic of healing promptly and efficiently.

An additional case of pertrochanteric fracture was recently reported by Wassink, of Amsterdam (*Surgery, Gynecology and Obstetrics*, December, 1920, p. 636).



Pertochantric fracture of the femur. Arrows point to plane of fracture. The cross-breaking mechanism is suggested and prompt and efficient healing forecast.



## MESENTERIC EMBOLISM IN A HÆMOPHILIAC\*

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AND

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MESENTERIC embolism is hardly to be considered an extremely rare condition since over four hundred cases of this interesting and decidedly dangerous entity have been reported. However, there are such unusual features in the case about to be presented as to make it worthy of discussion. In the first place, a correct pre-operative diagnosis was made which, according to Trotter's Monograph ("Embolism and Thrombosis of the Mesenteric Vessels," Cambridge, 1913), was done in only 4 per cent. of 366 collected cases. Another unusual feature and of much more importance to the patient is the fact that recovery followed the operation. The mortality in these cases is high, varying from 80 to 94 per cent. in various reports of collected cases. Another feature of particular interest in the present case is that the patient was a true hæmophiliac, of which fact we were not aware until after the operation, when the continued uncontrollable oozing of blood from the wound caused us to question the family only to learn of the previous hæmophilic history. This decidedly treacherous complication almost cost the patient her life at a time when she was just beginning to show signs of recovery, and had it not been for a prompt and voluminous transfusion she probably would have joined the usual 90 per cent. of mortalities, through no fault in diagnosis or technic, rather than being happily in the less than 10 per cent. class of recoveries. Hæmophilia is fortunately rare, and we are told that although transmitted by the female to the male offspring, it is seldom manifested in the female. There, again, is another unusual feature of our case. Having thus prefaced our report and given, we hope, sufficient reason for appearing in print, we shall present the case as follows:

A female, married, aged forty-five years, was admitted to the Jewish Hospital on September 10, 1920. She complained of acute pain throughout her abdomen. On the day before admission, after the patient had lunch, she felt nauseated, and on the same evening she developed sudden severe abdominal pain which was cramp-like in character. The pain became aggravated and was associated with almost continuous vomiting. The vomitus consisted of a greenish material at times and at other times it was very foamy but had no characteristic odor nor did it contain blood. The bowels were constipated, although she had taken magnesium sulphate, and an enema

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\* Presented before the Philadelphia Pathological Society, October 14, 1920.

had been given. The previous history is of interest in that twenty-four years ago bleeding from the rectum was noticed for the first time. The patient states that this bleeding was quite profuse and continued intermittently for two years. It stopped for several years and then recurred. The last attack was five years ago and lasted about two years, weakening the patient so much that she could hardly walk. This bleeding was always unaccompanied by pain and the condition had been diagnosed as intestinal ulceration. In June, 1920, the patient noticed a lump on the left shoulder about the size of an egg, which became black and increased in size until it involved the left arm as far down as the elbow-joint and extended across the chest. All of the involved parts became black and it took about eight weeks for the discoloration to disappear. The menstrual history was negative. On physical examination, the patient appeared to be in intense agony. She was in the dorsal position with the thighs flexed on the abdomen and any attempt to extend the thighs increased her pain. The abdomen was not rigid, but there seemed to be a moderate amount of tenderness in the lower left quadrant, but the pain, while more severe in this region, was general. No mass was palpable nor was there any noticeable distention. The peristaltic movements were well heard. Her temperature was normal, the pulse was 110 and there was no increase in the respiratory rate. The heart sounds were well heard and seemed to be normal except for a slight roughening of the first sound at the aortic area. There was no evidence of valvular vegetations. Throughout the examination the patient had persistent vomiting spells. From the foregoing facts there appeared to be no doubt in our minds that the patient was suffering from an acute intestinal obstruction, and from the acuteness of onset and violence of symptoms, together with the reference of pain toward the left lower quadrant, a diagnosis was made of either mesenteric embolism or volvulus of the sigmoid and immediate operation was advised. On opening the abdomen there was a gush of blood-stained fluid followed by the prolapse of a moderately distended intestine into the wound. On passing the hand down to the left lower quadrant a firm mass was felt which proved to be an intensely congested ileum which was on the verge of undergoing gangrene. The mesentery of this portion of the gut presented a beautiful picture of infarction. The involved area of gut was about 6 inches in length, the intestines below the diseased area appeared quite normal, while the bowel above showed graduated degrees of congestion, most marked, of course, as it approached the infarcted area. The diagnosis was by this time perfectly clear, and the patient's condition being fairly satisfactory a resection was decided upon. The diseased loop, together with several inches of the congested gut above the infarct and the accompanying mesentery, was removed. The open ends of the gut above and below the resection were inverted and closed and a lateral anastomosis was made and the operation

## MESENTERIC EMBOLISM IN A HÆMOPHILIAC

completed by tacking the omentum of the side of the anastomosis. The abdomen was closed without drainage. While closing the superficial tissues it was noticed that there was a slow but continuous oozing of blood, the origin of which could not be determined, and for this reason the patient was given an injection of normal horse serum on the table and the wound was closed particularly carefully, and firm pressure was made against it from without. Despite these precautions the oozing continued for twenty-four hours, and having tried all the usual local hæmostatics without success a transfusion was performed by the "Citrate Method," the patient receiving about twenty ounces of blood. Almost immediately the bleeding stopped, and aside from a well-marked reaction due to the transfusion the patient's condition became markedly improved. For the next few days she ran an irregular fever, followed by the development of a hæmatoma in the lower end of her wound which was not disturbed. Her temperature then became normal and in the course of about a week the wound expelled the hæmatoma and closed by granulation. Three weeks after the operation the patient was out of bed and went home shortly thereafter in good condition, and when last heard from was in perfect health.

Although the literature has been rather thoroughly studied by us we shall not review it in this report, but refer those interested to the papers of Jackson, Porter and Quinby (*Journal A. M. A.*, 1904, xliii, 43) and Eisenberg and Schlink (*Surgery, Gynecology and Obstetrics*, 1918, xxvii, 66), both of which contain excellent digests of the previous literature and reported cases. Several papers have been presented since these two, most of them reporting a single case ending in death. Exceptions may be noted in a series of six cases reported by Ross (*ANNALS OF SURGERY*, 1920, lxxii, 121) one of which recovered. Whether our case was one of arterial or venous obstruction we cannot positively state, inasmuch as hemorrhagic infarction occurs in both conditions. Furthermore, while we believe the condition was arterial we can only state that it was an embolism rather than a thrombosis, chiefly by the acute onset of symptoms. We agree with Eisenberg and Schlink (*loc. cit.*) that all of these pathological terms should be grouped together for clinical purposes under the term "mesenteric vascular occlusion."

The etiology of this condition is variable, as is the etiology of thrombosis and embolism elsewhere, but we believe that our case could hardly have been a thrombosis, inasmuch as the patient had not sufficient clotting power in her blood to cause normal coagulation, much less the abnormal coagulation of a thrombosis. However, there may be some relation between hæmophilia and thrombosis that we have not as yet learned. Another question worthy of conjecture is whether the intestinal hemorrhages from which the patient suffered in the past were due to her hæmophilic constitution or to a manifestation of another mesenteric

embolism, which finally cured itself, as in a case of Deaver's reported by Ross.

We have learned several important points in having treated this case, namely: (1) Sudden and *persistent* vomiting without apparent cause associated with *recurrent, severe* abdominal cramps should call for early abdominal exploration. (2) If the patient is in reasonably good condition, wide resection of the infarcted area with lateral anastomosis is the operation of choice. (3) Hæmophilic manifestations should be combated at the earliest moment by transfusion of at least 500 c.c. normal blood. No time should be wasted on horse serum, thromboplastin, etc., if results are not obtained within one hour or two.

TRANSACTIONS  
OF THE  
NEW YORK SURGICAL SOCIETY

*Stated Meeting held October 27, 1920*

The President, DR. WILLIAM A. DOWNES, in the Chair

RESECTION OF RIGHT SIDE OF COLON WITH MESENTERIC GLANDS FOR  
PAPILLARY ADENOCARCINOMA OF CÆCUM (THREE AND  
ONE-HALF YEARS POSTOPERATIVE)

DR. NATHAN W. GREEN presented a woman, aged thirty years, who was admitted to St. Luke's Hospital on August 19, 1916, for relief of a chronic left-sided salpingo-oöphoritis and subacute appendicitis.

On August 21, 1916, the left tube and the appendix were removed by Doctor Green. The appendix was 7 cm. long, much swollen and somewhat distorted, measuring from 1 to 1½ cm. in diameter. The Fallopian tube showed a lumen filled with granulation tissue on which were scattered epithelioid tubercles, some of which contained typical giant-cells. No tubercles were seen in the appendix or ovary (Dr. F. C. Wood). The ovary contained some gelatinous cysts. She was discharged cured on September 8, 1916.

On October 13, 1916, she was readmitted with a diagnosis of tuberculous salpingitis of the right side, having been well until one week before admission, and on October 17, 1916, the right tube, ovary, and the uterus were removed under Dr. Walton Martin's direction by Doctor Venable, then house surgeon. The pathological report was again tuberculous salpingitis and tuberculous endometritis, fibrous uterus and chronic oöphoritis. On November 11, 1916, she was again discharged cured.

On January 13, 1917, she was again admitted with symptoms of incomplete intestinal obstruction with the history that since being last discharged she had not been well and had had a great deal of abdominal pain in the right side. She had a poor appetite and was constipated and had lost weight. On physical examination she had a soft abdomen without muscular spasm. In the right lower quadrant was definite tenderness and a soft tender mass was felt on palpation. Pelvic examination showed this mass to be above the brim of the pelvis. It was soft, tender, and rather freely movable. On January 20, 1917, an exploratory laparotomy and ileosigmoidostomy was done by Doctor Green.

*Pathological Findings.*—The uterus, tubes, and ovaries had been ablated. There were numerous bands and veils of adhesions about the abdominal

cavity, most numerous about the large gut. No distinct constriction of the gut could be found. *The longitudinal bands of the ascending and transverse colon were hypertrophied, while those of the descending colon were not.* The appendix was absent, having been removed. The wall of the cæcum was thickened and surrounded by adhesions. A large cauliflower-like polypoid tumor could be felt on the interior of the cæcum, the ileo-cæcal opening was patent.

*Operative Procedure.*—The abdominal cavity was explored through a right rectus incision, excising the old scar. A side-to-side anastomosis was made between the lower end of the ileum and the sigmoid. This presented the easiest procedure and was made use of as the patient was not in good condition.

On February 6, 1917, she was discharged improved, seventeen days after operation. There were no symptoms of intestinal obstruction and she was sent to a convalescent home to return when her general state should be improved.

April 15, 1917, she was readmitted with the following interval history. After leaving St. Luke's Hospital she went to the country for two months and improved greatly; gaining in weight and feeling better. Two weeks previous to the last readmission the patient began to have severe cramping pain in lower right side, with vomiting. These attacks were repeated. There was no fever and bowels moved somewhat daily. Since the onset of these symptoms she had noticed a hard tumor in the right lower quadrant.

On April 18, 1917, an operation for resection of lower ileum, cæcum, ascending and part of transverse colon was performed by Doctor Green under gas and ether anæsthesia.

*Pathological Findings.*—Numerous rather firm adhesions between intestines and anterior abdominal wall. The cæcum was surrounded by a network of firm stringy adhesions which completely enveloped it. The cæcum was also quite mobile. The ileosigmoidostomy which had been done at a previous operation was found to be in good condition and well open, admitting the tips of three fingers. The cæcum contained a rather large, firm, apparently pedunculated, freely movable tumor about the size of a lemon. The glands of the mesentery supplying the cæcum were enlarged, several being 3 cm. in diameter.

*Operative Procedure.*—An incision was made along the site of former operation (right rectus). Adhesions to anterior abdominal wall were divided and ligated. The cæcum was mobilized by dividing adhesions and ligating whenever bleeding occurred. The mesentery of the transverse colon was pierced at about its middle and the mesentery of the ileum was pierced slightly below the anastomosis. Strong intestinal clamps crushed the transverse colon and ileum at points selected for resection. The mesentery of the cæcum, ascending and transverse colon to right of the colica media artery, and also of the lower ileum was ligated

## RESECTION OF RIGHT SIDE OF COLON

and divided in stages, thus completely freeing this part of the intestinal tract to be resected. Double ligatures of number one chromic gut were placed around the ileum at the point crushed with the clamp, and securely ligated; a purse-string of number one chromic gut was placed around the ileum below the ligature. The ileum was then divided with the actual cautery distal to ligature. The stump of the ileum was then inverted under the purse-string suture and two reinforcing number one chromic gut sutures still further secured the site of inversion. The

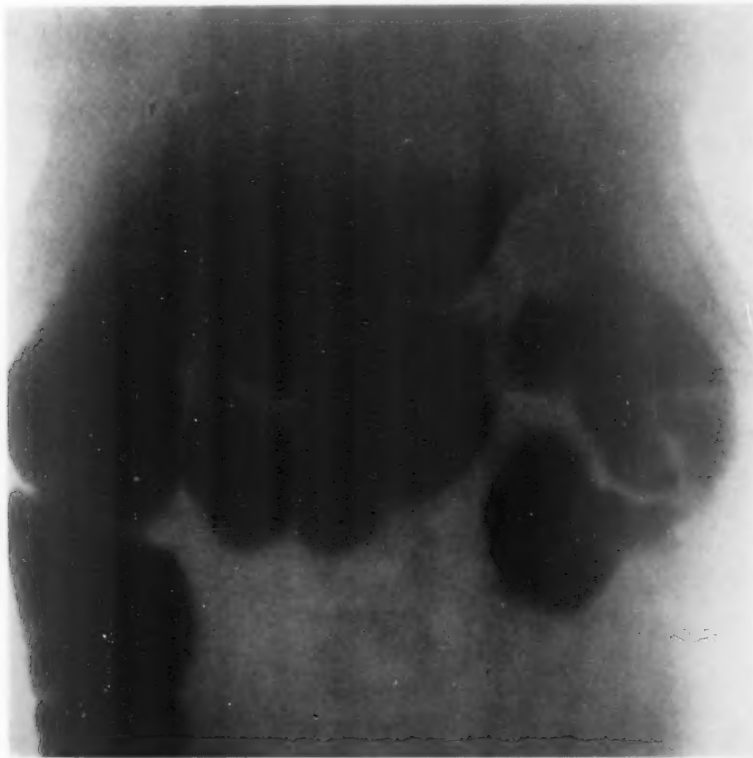


FIG. 1.—Right-sided colectomy for papillary adenocarcinoma of the cæcal juncture. Plate taken October 22, 1919.

transverse colon was similarly crushed and ligated at the point selected for resection. The stump was treated in the same way as the ileum. The enlarged glands in the mesentery were then dissected out and removed. All bleeding points were carefully ligated. The stump of the transverse colon was pulled into the upper angle of the incision in case of leakage. The wound was closed in layers with additional retention sutures of silkworm gut. There was no drainage. The patient was discharged cured on May 8, 1917, twenty days after the operation, and has been well since.

*Pathological Report.*—By Dr. F. C. Wood. Papillary adenocarcinoma

of cæcum. Inflammatory reaction in mesenteric lymph-nodes. (The lymph-nodes show an excess of fibrous tissue. The round-cells are rather few in number.)

This case is presented because of the coincidence of tuberculosis and carcinoma in the lower abdomen. Also to show the relatively non-malignant form of carcinoma which occurs in the cæcum. Also further to show that numerous and enlarged mesenteric glands need not necessarily be a contraindication to attacking surgically a carcinoma situated in the caput coli. A further point of interest is brought out by Dr. L. T. LeWald's röntgenogram, *viz.*, that the blind pouch of the remaining colon has not become overdistended.

The patient has been in the medical ward of the hospital this summer for a pyelitis following the drinking of a glass of lysol by mistake for some other liquid. She is now entirely well.

DR. DE WITT STETTEN corroborated what Doctor Green had said regarding the fact that enlarged mesenteric glands were no contraindication to a radical operation. He said that one and a half years ago he had resected a carcinoma of the splenic flexure, in which the mesenteric lymph-nodes were so enlarged that he felt that the operation was practically hopeless. Many of the glands were as large as hazel-nuts and some were even larger. The involvement in this case was so extensive that he was on the point of doing a palliative colocolostomy. Nevertheless, he did perform a radical operation, excising a large V-shaped section of the mesentery. The patient to date has gained over thirty pounds and up to the present is apparently entirely free from recurrence. Pathological examination of the glands showed merely inflammatory changes and no evidence of cancerous deposits.

#### RESECTION OF THE UPPER PART OF THE HUMERUS, THE OUTER END OF THE CLAVICLE AND THE HEAD OF THE SCAPULA FOR MEDULLARY SARCOMA

DR. N. W. GREEN presented a man operated upon three and one-half years ago. Before coming under Doctor Green's observation the man had been healed by the X-ray, and apparently the treatment had inhibited the progress of the malignant growth for a while. However, there was an extensive dermal traumatism which did not heal. The man was admitted to the City Hospital suffering great tortures, and it was thought the arm would have to be amputated. The patient, however, begged that the arm be saved, and so an extensive resection involving the outer end of the clavicle, the head of the scapula, and 4 inches of the humerus (Fig. 2) was done, and a plaster case was applied. The wound did not heal readily, particularly the part that was traumatized by the Röntgen therapy, because in resecting one had not kept far enough away from the scar tissue; but eventually it had healed up.

## RESECTION OF UPPER PART OF HUMERUS

The pathological examination was made by Doctor Larkin at the Strecker Memorial Laboratory, and showed a small spindle-celled sarcoma (Fig. 3). For a long time crusts persisted at the end of the clavicle and over the clavicle, and a little over the shoulder. There was still some telangiectasis apparent, due to the Röntgen burn.

Doctor Green said he had hoped to obtain a result that would enable



FIG. 2.—Gross specimen, resection head of humerus, outer end of clavicle and head of scapula.

the man to feed himself, but there was now complete bony ankylosis between the scapula and the humerus.

The interesting point was the way in which the Röntgen treatment had affected the skin and muscles and had apparently limited the growth of the sarcoma. The muscle-fibres were as silvery as the scales of a fish. On cutting the bone, it was found filled with spindle-celled sarcoma.

The patient is now well and able to do a little work about his place in the country.

DR. ROYAL WHITMAN said that the brace evidently increased the de-

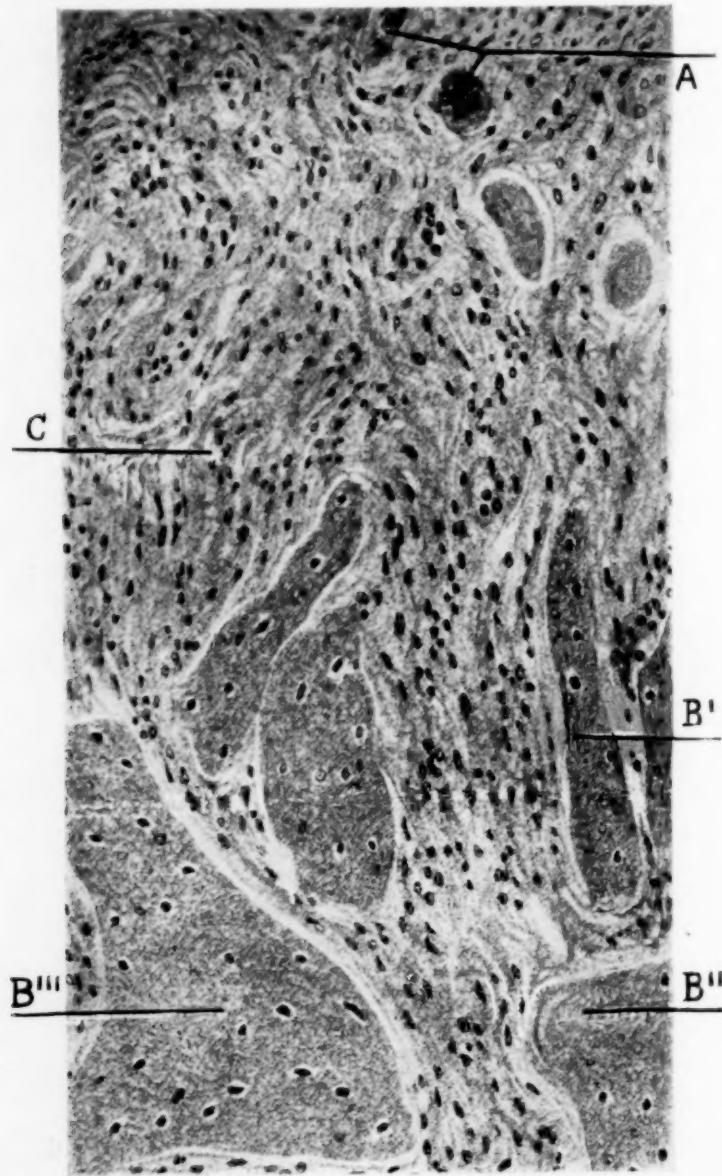


FIG. 3.—Microphotograph of section of head of humerus (Dr. Larkin).

formity. If it were removed the rotation of the scapula would permit the arm to be lowered as in the cases of paralysis in which the humerus had been intentionally fixed to the scapula in the same relation.

## INFILTRATING CARCINOMA OF THE BLADDER

### INFILTRATING CARCINOMA OF THE BLADDER

DR. EDWIN BEER presented this patient to call attention to the fact that it was just possible that a preliminary radiation of malignant tumors might aid the surgical procedure in obtaining curative effects.

This man, now sixty-two years of age, began to have typical symptoms of tumor of the bladder, hæmaturia, frequency and later pain about two years ago. The cystoscopic diagnosis made by another surgeon was papillary carcinoma. The patient was treated with cross-fire X-ray through the abdomen and radium through the rectum for many weeks. He finally stopped treatment, as in addition to the pains in the bladder he now had severe pains in the rectum. When the patient was first seen by Doctor Beer about eleven months ago, he had a large ulcerating papillary tumor of the left lateral and the posterior walls, which was easily palpable through the rectum as a mass the size of an orange. Owing to the extent of the growth the question of total cystectomy had to be considered. The operation to be described in the paper of the evening was done on the patient more than ten months ago. The tissues were found baked together so that dissection was unusually difficult. The perivesical fat and adjacent iliac glands were removed with about two-thirds of the bladder, so that when the organ was repaired it was the size of a sickle pear. The microscopic examination of the gland did not show malignancy. The bladder growth was an ulcerating infiltrating carcinoma of huge size, but fortunately did not involve the ureters, though it came to within about 1 cm. of the left ureter. The patient made an excellent though slow recovery. His bladder capacity gradually developed so that now his frequency is one to two hours by day and three times at night. He appears to be in excellent health and no signs of recurrence manifest themselves as yet.

From a rather extensive experience in this field, Doctor Beer felt certain that there would be a speedy recurrence of the growth in this patient. In view of the course of events, which were so unusual, Doctor Beer believed that the preliminary radiation might have done much towards this good result, and it was with this in mind that he asked the patient to present himself to-night.

DOCTOR GREEN said that he appreciated the efforts Doctor Beer had made to avoid the implantation of cancer cells. Doctor Green recalled that five years ago he had shown a case of gelatinous carcinoma of the bladder, in which the carcinoma was very large and involved the fundus. Doctor Bugbee did the cystoscopic examination on this case. Doctor Green then performed a partial cystectomy. Three years later in the scar below the umbilicus a small hard nodule appeared. It was discrete, but he concluded that it was a recurrence of the cancer from implantation and excised it. The recurrence was the same type as the original—rather

non-infiltrating. It was now two and one-half years since that had occurred and five and one-half years since the first operation. However, it must be remembered that cancers differed greatly from one another in malignancy. This carcinoma was doubtless not as malignant as the one in Doctor Beer's case, which had eroded a large-sized hole and formed a diverticulum in the bladder.

DR. JOSEPH WIENER said that Doctor Beer had operated upon him for a papilloma and he thought it might be interesting to the members of the Society to hear the inside history. Judging from the impression Doctor Beer gave him, he had an idea this was a major operation and he rather dreaded it. The post-operative disturbance was practically nothing. He awoke three hours after the operation with no nausea, vomiting or wound pain. For about three days he suffered very severe bladder spasms, not controlled by morphine at all. These spasms came on at almost hourly intervals for the three days. When the suprapubic tube was removed and Doctor Beer's cup applied, there was practically no leakage, and the patient was perfectly dry most of the time. Another advantage that this cup had was that instead of being open only at the lower part so that the patient had to lie on his back, this one was open at both sides, so that the patient could lie on either side without there being any leakage. Doctor Wiener said he remained in the hospital only nine days when he left for his out-of-town home, contrary to advice, and his recovery from that time was very rapid. He had taken out the stitches himself. There was some pain when he first voided, and the bladder spasm was very painful, but from the time the suprapubic tube was removed he had taken no drugs. A suprapubic fistula remained which took forty-two days to entirely heal.

DOCTOR BEER said that most men saw but few of these cases and that the results of the casual operator were far from attractive. In going over the results that had been published in tumors of the bladder it was most astonishing to see how frequently even benign growths recurred after operation. Naturally with malign tumors the results were even worse. Up to ten years ago some writers of experience recommended hands off in all bladder neoplasms. Though one could and did obtain an occasional cure of bladder tumors without using the technic described in this paper, if one followed this technic one would be surprised to see how frequently, almost regularly, in the benign papillomata, in the papillomatoses, and in the papillary carcinomata one avoided recurrences. For the infiltrating growths one could not say as much.

The technic described to-night was a gradual evolution, and had been in use for six years, during which time Doctor Beer and his associates operated upon some thirty-eight cases, all unsuited for one reason or other to the high frequency cauterization method. During the past few months there were three cases in which this technic could not be employed, and his experience in these three cases contrasted so vividly with his experience when he adhered carefully to the technic outlined, all

#### MULTIPLE DIVERTICULA OF THE UPPER ILEUM

three cases having rapid recurrences either in the bladder incision or in the wound, that he felt sure he was working along the correct line when he emphasized the importance of doing everything to avoid implants.

While talking of this matter, one case of papillomatosis, the result of wide dissemination of papilloma by the previous operator, came to Doctor Beer's mind. Eight such cases had been treated by this technic, most of them having innumerable tumors in the bladder, following an attempt at surgical cure. The case referred to above had just been reexamined some three years after the operation by Doctor Beer and the bladder found absolutely normal. This was an excellent test of the cautery, etc., technic described as the patient had had four previous operations in this country and abroad for papillomata of the bladder. Invariably the growths recurred rapidly, *i.e.*, implants were strewn over the bladder and when he was last operated upon the bladder was well filled with innumerable papillomata. By using the described technic in this and the other cases it was gratifying to see how almost regularly implants and therefore recurrences were obviated.

One must not be afraid to use the cautery thoroughly, and one must have an excellent exposure so that the cautery could get at every suspicious spot. Despite an hour's use of the cautery (Paquelin) (which with the electric cautery is never necessary), the patients did not suffer any more than the ordinary cystostomy cases.

In closing, Doctor Beer again emphasized that he believed the technic described in detail in his paper was going to mean a great deal to all those patients who for one reason or other could not be treated transurethtrally with the high frequency cauterization method, *i.e.*, (1) Papillomatoses cases. (2) Intolerant to cystoscopy cases. (3) Tumors at the neck or elsewhere that bleed enough to embarrass the cystoscopist. (4) Inaccessible tumors. (5) Papillary carcinomata. (6) Infiltrating carcinomata.

#### MULTIPLE DIVERTICULA OF THE UPPER ILEUM

DR. DE WITT STETTEN presented a well-nourished man aged thirty-eight years, who had been complaining for several months of rather frequent, acute attacks of severe abdominal pain. These attacks were referred vaguely to the upper abdomen, were accompanied by gastric distress and nausea, and lasted for several hours. During the attack, the upper abdomen was slightly sensitive to pressure, but no definite localization could be determined. After the attack had subsided, the patient felt perfectly well. Proper attention to the bowels, a rigid diet, and alkalies seemed to have no effect in preventing a recurrence of the attacks. Examination of the abdomen in the intervals between the attacks revealed nothing but a moderate-sized umbilical hernia. The attacks suggested biliary colic, and a careful radiographic study of the gall-bladder region and gastro-intestinal tract was made by Dr. L. G. Cole. The gall-bladder region, stomach, pylorus, and duodenum were negative. An

unusually long, tortuous, and segmented appendix with retention ninety-two hours after the enema was demonstrated. Throughout the entire colon, especially in the descending colon and sigmoid flexure, numerous diverticula of varying size could be recognized. In addition to these, there were seen two large, almost spherical pockets of barium about  $1\frac{1}{2}$  inches in their longest diameter. One was slightly smaller and more ovoid than the other. They appeared almost immediately after the ingestion of the meal and were still quite filled after seventy hours, even after



FIG. 4.—Radiograph twenty-eight hours after meal and after catharsis and ten minutes after enema and before evacuation. Shows two large diverticula of the upper ileum and multiple diverticula of the colon.

the administration of a cathartic. The larger was still fairly full one hundred and twenty hours after the meal. These pockets moved around to various parts of the abdomen and also in relation to each other, the smaller, however, always appearing below and to the right of the larger (Figs. 4 and 5). They were evidently sacculations connected with the small intestine.

On December 9, 1919, the speaker performed an exploratory laparotomy. The umbilical hernia was excised and the appendix removed. The gall-bladder was examined and found to be normal and free from

#### MULTIPLE DIVERTICULA OF THE UPPER ILEUM

calculi. Multiple diverticula of the colon were seen, but they were not inflamed, and therefore were not disturbed. Near the upper end of the ileum were found the two large pouches, some twenty inches apart, corresponding in size to the X-ray shadows. The lower one was somewhat larger than the upper. They seemed decidedly injected. Both were on the same side of the gut, at the mesenteric border, rather sessile, and dissecting under the one leaf of the mesentery. The mesenteric leaf was split, and the pouch, in each instance, was freed and ligated at its

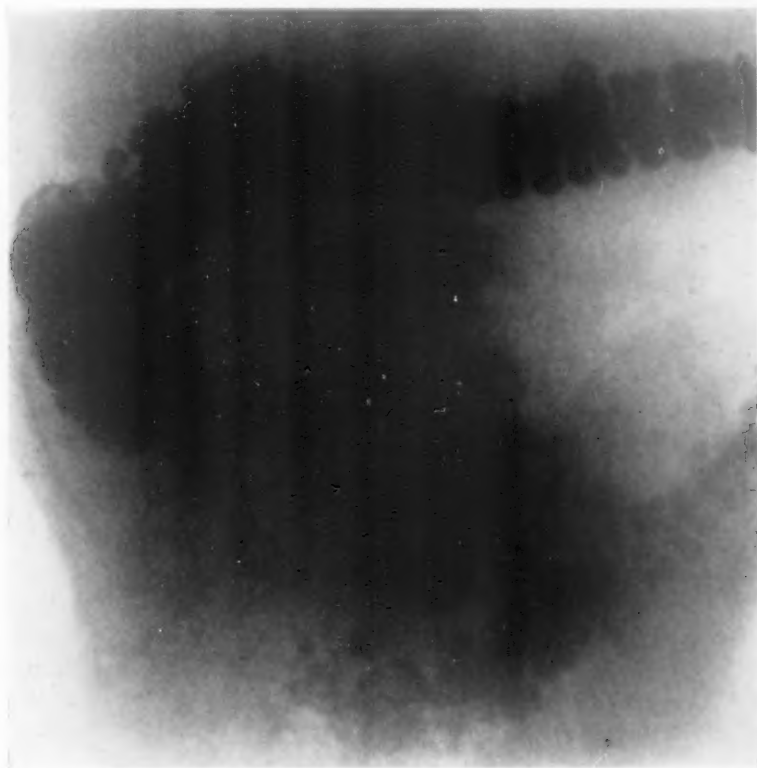


FIG. 5.—Radiograph forty seven hours after meal and nineteen hours after enema. The two large diverticula of the upper ileum are still filled and are lying in juxtaposition. The long, tortuous and segmented appendix is also still filled and visible. Numerous diverticula of the colon can, likewise, be demonstrated.

junction with the intestine. After amputation with the cautery, the stump was buried by a purse-string suture of silk. The abdomen was closed in the usual manner. The patient had an uneventful convalescence and has been entirely free from any abdominal symptoms since the operation.

The diverticula were quite similar in their structure to the false or mucous membrane diverticula found elsewhere in the gastro-intestinal tract, namely, herniæ through the muscular coat. Judging from the extreme degree of retention, as demonstrated by the radiographic study,

their injected appearance at operation, and the complete freedom from symptoms since their removal, Doctor Stetten said he felt we were justified in assuming that they were the true cause of the acute abdominal attacks, probably manifestations of inflammatory or mechanical disturbances, resulting from the retention of intestinal contents. It was conceivable that these pouches might have led to much more serious trouble had they not been extirpated.

DR. JOHN F. ERDMANN said that while diverticula of the small intestine were quite rare as compared with the frequency of this condition in the large intestine, he had seen quite a number of diverticula of the small intestine. He had just recently removed a diverticulum from the junction of the ileum and cæcum. He had had two cases of the cæcum within the last four or five years in which the diverticulum had become gangrenous.

DOCTOR DOWNES mentioned that he had operated on a diverticulum in the hepatic flexure. At the operation he found three diverticula in the ascending colon, but none in any other part of the intestine.

DR. PARKER SYMS cited the case of a patient in whom gall-bladder trouble was suspected and an extensive examination made for gall-stones. In the course of the X-ray examination a diverticulum was shown in the neighborhood of the hepatic flexure. The filling up of the diverticulum with barium relieved the symptoms, so the patient continued to treat himself along this line.

DOCTOR STETTEN said that these diverticula were the typical false or mucous membrane diverticula in which the mucous membrane and submucosa came through the muscular coat. The diagnosis reached before operation was diverticula of the upper part of the small intestine. This was as accurate as one could be. As the sacs filled almost immediately after the barium meal it was obvious that they were high up in the intestinal tract. Doctor Cole, who made the X-ray examination, was actually quite thrilled when he saw the plates. Of course, he had seen many cases of diverticula of the colon, and also of the duodenum, but this was the first time in his extensive experience in gastro-intestinal radiography that he had been able to demonstrate radiographically a diverticulum of the jejunum or ileum.

*Stated Meeting held November 10, 1920*

The President, DR. WILLIAM A. DOWNES, in the Chair

#### BONE GRAFT OF HUMERUS FOR NON-UNION

DR. FRANZ TOREK presented a man who fractured his humerus nineteen and one-half years ago. Wiring of the fragments was resorted to without benefit. Unable to use the arm. On January 15, 1920, he came under Doctor Torek's treatment at the Lenox Hill Hospital, requesting that his arm be amputated rather than that he should again undergo prolonged treatment which he felt sure would be futile.

## OPERATION FOR UNUNITED FRACTURE

The right arm presented an extreme angular deformity near the middle where a false joint existed. The muscles were atrophied. The bone fragments were out of alignment and the silver wire broken.

On January 24, 1920, at operation by Doctor Torek, the ends of the bone were found embedded in a mass of fibrous tissue involving the muscles. The muscles and fascia were dissected free from the bone ends, and the bone ends were sawed off square. Parallel cuts about  $\frac{1}{2}$  inch apart in the humerus were made with an electric saw to remove a portion of bone 3 inches long from the upper fragment and a portion  $1\frac{1}{2}$  inches long from the lower fragment. These excised portions were then transposed so that the longer graft was placed below and the smaller graft above. In this way the longer graft bridged the two fragments of the humerus. The grafts were held in place by chromic-gut sutures through drill holes in the shaft. A plaster case was applied. The patient was discharged from the hospital ten days after the operation. The case was removed seven weeks after the operation and the union was found to be firm. The patient has full use of his arm.

## BONE GRAFT OF TIBIA

Doctor Torek presented this patient whose history, he said, was very similar to that of the first case inasmuch as other methods of treatment had been tried. This man fractured his leg in 1914. He was first treated in the ordinary way and a plaster splint applied. This treatment was unsuccessful. The same physician who had given this treatment then used silver wire, and this also was unsuccessful. He was operated upon in a hospital in 1915, when a Lane plate was applied. This, too, was unsuccessful and hyperæmia treatment was instituted by the application of a Bier's bandage. The latter treatment was likewise unsuccessful. Blood was then injected at the fractured ends of the bone in the hope of stimulating nutrition. Finally, in January, 1916, he came under Doctor Torek's care.

At operation, as in the first case, he took a longer graft from the upper fragment and a shorter one from the lower fragment. These he transposed as in the first case shown, thus filling the opening, the only difference being that in this instance the graft was taken out with the chisel instead of with the electric saw as in the first case.

The man now uses his leg perfectly well, the only difference between this leg and the other is that there is some shortening which is unavoidable due to the sawing off of the fibrous ends of the bone.

## THE RECONSTRUCTION OPERATION FOR UNUNITED FRACTURE OF THE NECK OF THE FEMUR

DR. ROYAL WHITMAN presented a woman, aged sixty-five years, on whom he had operated for ununiting fracture of the neck of the femur in August, 1916, by what he would call the reconstructive method.

In brief, it consisted in removal of the head of the femur. The base of the trochanter was then cut through at its base in the line of the neck and was transplanted to the outer aspect of the shaft.

In this manner a neck was reconstructed by adding the area from which the trochanter had been removed to the remnant that persisted. This extremity was then thrust completely within the acetabulum, the limb being abducted about  $25^{\circ}$ , and the trochanter with its attached muscles was attached to the outer surface of the shaft as far downward as the tissues would permit. Thus a muscular sling was provided to support the limb, while the projecting trochanter assured the required leverage for muscular control. When the limb was abducted the tissues

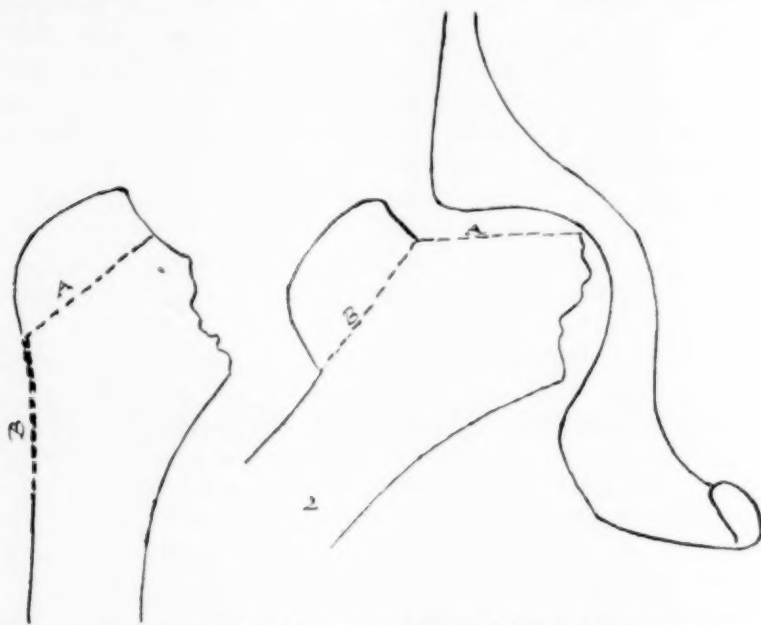


FIG. 1.—1. The upper extremity of the shaft. A, the lines of separation of the trochanter. B, the point to which it is to be transplanted. 2. Showing the reconstructed neck inserted in the acetabulum at about 25 degrees abduction.

were attached to the trochanter and one could place the trochanteric flap upon the femur and hold it in position by sewing the muscles over it. In recent cases he had bored a hole through trochanter and the shaft of the femur and fastened the two with kangaroo tendon; this, he felt, was a little safer.

The patient presented, the first of a series of cases treated by this method, would illustrate what might be accepted as a final result. She was before the operation completely disabled, suffering almost constant pain. She now was free from discomfort. The limp was no greater than that of the so-called favorable results of conventional treatment and the range of controlled motion was sufficient for all functional requirements.

Doctor Whitman said that ununited fracture of the neck of the

## BONE GRAFT FOR UNUNITED FRACTURE OF TIBIA

femur was a painful as well as a crippling disability for which, except in the early cases in which bone grafting seemed feasible, there was at present no accepted treatment. He thought the reconstruction operation was a practical solution of the problem.

A large number of lantern slides were shown illustrating the details of the operation and the results as demonstrated by X-ray pictures of the cases.

## EPITHELIOMA IN SINUS OF OLD OSTEOMYELITIS

DR. JAMES M. HITZROT reported a case of epithelioma in a sinus of an old osteomyelitis and exhibited the specimen and röntgenograms. The patient was a man, aged fifty-eight years, who thirty years before admission to the New York Hospital had been kicked on the right shin by a horse. Several days afterward an abscess developed on the leg, and subsequently he was operated upon for an abscess in the bone. He had had in all seven operations for an osteomyelitis of the tibia. Five weeks before his admission to the hospital the pain had increased and the discharge which before that had been simply a small quantity became foul smelling and profuse. The clinical diagnosis on admission was perfectly obvious. Around the region of the sinus there was a purplish-blue fungating mass resembling epithelioma which bled rather easily when touched (Fig. 2).

Amputation was done through the upper third of the tibia, using anterior and posterior flaps, care being taken to make the amputation in healthy normal bone. The specimen, somewhat mutilated, owing to the fact that the pathologist had removed a section, showed the region of the ulcerated area on the lower portion and the region of the epitheliomatous mass.

The patient made an uninterrupted convalescence. There were no lymph-nodes in the groin. The patient had gone out of the city, but so far as Doctor Hitzrot knew there was no evidence of recurrence. The case was reported because of the unusual complication in osteomyelitis.

DR. JOHN F. ERDMANN recalled three somewhat similar cases in which he had performed amputation. One of these cases was in the Alms-house, another in the Gouverneur Hospital, and the third in the Post-Graduate Hospital. They were diagnosed as carcinomatous degeneration about the sinus.

## BONE GRAFT FOR UNUNITED FRACTURE OF THE TIBIA

DR. JAMES M. HITZROT presented a man, aged twenty-six years, who entered the New York Hospital in July, 1920, with a history of fracture of the left tibia from a shrapnel wound received in France twenty months before admission. Fourteen months before admission he had a bone-grafting operation at General Hospital No. 31, a rib having been used for the graft. Four months before admission he was discharged as cured, and was given a 15 per cent. disability.

On admission there was an ununited fracture in the lower third of the left tibia with false motion at the front line, and a definite anteroposterior angle which had been slowly increasing. The X-ray showed



FIG. 2.—Epithelioma in sinus of old osteomyelitis.

an ununited fracture with remnants of the graft above and below the line of fracture. On July 9th, a graft  $\frac{3}{8}$  by  $7\frac{1}{2}$  inches, taken from the left tibia above the line of fracture, was placed in a prepared groove across the line of fracture and countersunk in the cancellous bone of the

## INTESTINAL RESECTION FOR OBSTRUCTION

lower fragment. Drill holes were made through the sclerotic lower end of the upper fragment, partly to fasten the graft in place by bone pegs and also to allow it (the sclerotic bone) to become vascularized. The lower end of the upper fragment resembled ivory in its density and was extremely hard, with no medullary cavity, while the lower fragment was porous and filled with fatty marrow. The case was shown to illustrate: (1) The failure of the rib graft. In Doctor Hitzrot's experience the rib was not sufficiently strong to act as a graft in weight-bearing bones. (2) Fracture of the tibial graft inserted at the operation, and repair of the fracture in the tibia despite this fact. (3) The drilling of the sclerotic bone to allow for more rapid vascularization. (4) Countersinking of the graft in the lower fragment to get good endosteal contact and to help in fixing the graft—a method which helped when one had to deal with a short fragment at one side of the fracture.

The man has now solid union and the X-ray fourteen weeks after operation shows a good mass of new bone across the line of fracture. In reply to the question why there was porosity in the lower fragment with a sclerosis in the upper fragment, Doctor Hitzrot said he was unable to explain why there was porosity in the lower fragment and sclerosis in the upper fragment, unless the sclerosis was the result of an inflammatory process and the porosis the result of disuse. In regard to the question of periosteum, he had had the experience that endosteal contact was more important than periosteal contact, and he had not been using periosteum in his transplants for a long time and thought he obtained more successes without than with periosteum.

## INTESTINAL RESECTION FOR OBSTRUCTION FOLLOWING APPENDECTOMY

DR. J. H. KENYON presented a man aged twenty-six years, born in Austria, a furrier by occupation, who was admitted to the Fordham Hospital, February 19, 1920. Five months before that time he had been operated on at another hospital in this city for acute appendicitis with abscess. He had been sick four days. The appendix was removed and a rubber tube about one-half inch in diameter was inserted for drainage. On the third day two smaller tubes were inserted alongside of the larger one for irrigation which was done every day. The tubes were not removed until the twelfth day, when a gauze drain was substituted. He left the hospital on the seventeenth day, but the wound was not healed until several weeks later. There was some weakness and bulging of the scar and his physician told him that another operation would be necessary.

Except for a poor appetite, some abdominal discomfort which he described as indigestion and some constipation he felt fairly well, though he said that his stools showed a small amount of blood occasionally.

On the day of his admission to the Fordham Hospital, five months after his appendectomy, he was awakened at 3 A.M. with severe pain in

his abdomen, not particularly localized, but rather more severe in the lower right quadrant. An hour later he vomited greenish material and his physician who saw him about this time advised him to go at once to the hospital for an operation, but he decided to wait. Enemata returned clear, no gas or fecal material was passed; morphine did not relieve the pain. Vomiting continued at frequent intervals all day, and at 7 P.M. became fecal, and then he decided to go to the hospital. When seen shortly after his admission, and twenty-one hours after the onset of the pain, he was acutely ill, had severe abdominal pain and was vomiting at frequent intervals. The abdomen was distended, tympanitic, and quite tender in the right lower quadrant, especially over the old scar which showed a diffuse bulging rather than a strangulated hernia through a small opening. Temperature, 101.5°; pulse, 98; respiration, 20.

The operation was started at once. When the abdomen was opened through a right rectus incision, just above the old one, bloody fluid escaped. Exploration with the finger showed the inner margin of the former incision to be free from adhesions, so the opening was enlarged downward in that direction. The abdominal wall along the outer margin of the opening and also the thin portion of the scar were adherent to the anterior surface of the cæcum. These adhesions were liberated. The small intestine was distended and near the cæcum was deep purple in color and rotated, counter clockwise one and a half turns. When this loop was untwisted a strong band could be seen passing from a point near the ileocecal junction to the mesentery, tightly constricting the two legs of this loop; when this band was cut, the normal lumen and curvature were restored and the intestine could be lifted up into the wound. Hot, moist pads were applied, but there was no improvement in the condition and a resection became necessary. The portion removed measured fourteen inches.

The patient's condition was not very good, and it seemed that an anastomosis with a Murphy button would be quicker than the more preferable one with a suture. The distal stump was rather short, only about one inch long, and it was thought that the button might pass more readily if one-half were placed directly in the cæcum; accordingly, the distal stump was closed with a continuous suture of chromic catgut and then inverted with a purse-string suture of linen and an end-to-side anastomosis was made into the anterior surface of the cæcum about one inch above the ileocecal junction. Purse-string sutures of linen were used to hold the button in place, interrupted sutures of catgut were used in the mesentery but no reinforcing peritoneal sutures were placed.

A cigarette drain was inserted down to the pelvis and brought out at the lower end of the wound. The usual closure in layers was made, with plain and chromic catgut, silkworm gut and silk for the skin. No special attempt was made to repair the hernia because of the patient's condition. Usual dressing.

## INTESTINAL RESECTION FOR OBSTRUCTION

The patient made a good recovery. Daily enemata, beginning the day after the operation, were effectual. Soft diet was given on the third day. No cathartic was given by mouth until the eleventh day. The cigarette drain was loosened and shortened each day and entirely removed on the fifth day. Sutures out on the eighth day, wound strapped. Patient sat up on the twentieth day and left the hospital at the end of four weeks.

The button was never recovered but as shown by the X-ray pictures must have been passed some time between the fifteenth and twenty-fourth day.

At the present time, nine months after the operation, the patient feels very well, has a good appetite, normal movements without any blood. The hernia in the scar is about the same as before and will require another operation.

DR. JOHN F. ERDMANN stated that he had not used the Murphy button for some ten to twelve years because he had had the misfortune to have one slough through the intestine; ever since that time he had used suture, claiming suture to be quite rapidly applied in the skillful operator's hands and that danger of slough and foreign-body retention were done away with.

DOCTOR TOREK said he saw no objection to using a Murphy button. He recalled an unpleasant experience with an end-to-end anastomosis of the small intestine by the suture method. Obstruction followed and the patient died. Autopsy showed the obstruction to be due to bleeding into the tissues at the site of the end-to-end suture which was of such a character that the lumen of the gut was closed by the bleeding. That, of course, would not have happened if a Murphy button had been used.

DR. EUGENE H. POOL said he had not been using a Murphy button if it was possible to avoid it, for the reason that occasionally it had been known to slough through and cause sad results. He recalled a case operated upon by another surgeon in which a Murphy button was used for a gastroenterostomy after pylorectomy. The patient seemed to be making good recovery and after three or four weeks was able to go out driving. Then she was seized with an attack suggesting acute appendicitis. The patient died and the Murphy button was found about twelve inches from the ileocecal junction. It had perforated through the wall of the intestine and about it was quite an accumulation of pus. A Murphy button, like any foreign body, is likely to cause obstruction. If arrested it is liable to ulcerate through and should never be used where its arrest is likely to occur. In this connection Doctor Pool also recalled a case reported by a British surgeon of a boy who had sustained rupture of intestine at duodeno-jejunal junction. The duodenal end was closed and a gastro-jejunostomy done with button. The button dropped into stomach, passed to the blind duodenal loop, ulcerated through, and caused death.

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DOCTOR DOWNES said he understood that a well-known surgeon had been quoted as saying that the Murphy button would soon be passed along with the various relics of antiquity. It had answered a tremendous purpose when it was brought out, but now that the use of the suture had been perfected he thought that most surgeons were agreed that suture was better and that the use of the button was seldom indicated.

### TORSION OF THE OMENTUM WITH ACUTE APPENDIX

DR. JOHN F. ERDMANN presented a boy, aged fourteen years, who was admitted to hospital on October 18th, with a history of onset of appendicitis. He complained of nausea, vomiting and umbilical pain, localization of pain in the loin and in the midway portion of the right half of the abdomen. Thinking the appendix might be one of those with non-rotation, the incision was made rather high. The appendix was found floating rather free. Further exploration revealed a dark mass in the neighborhood of the gall-bladder which proved to be the right half of the omentum, twisted three times from right to left on itself, which was necrosed. The necrosed mass was excised and the suppurating appendix was removed.

Doctor Erdmann said that this was the first case of strangulated omentum that he had seen in thirty years' experience, though he had heard a few such cases reported and there were a few described in the literature.

DR. LUCIUS W. HOTCHKISS recalled that he had shown a case before the society several years ago (1907) in which torsion of the great omentum had occurred. In this case symptoms had followed the spontaneous reduction of a right-sided inguinal hernia which became temporarily irreducible. A large mass of omentum twisted on its vertical axis, contra clockwise, about eight times, close up to the transverse colon, was removed. It was beginning to show necrosis at the tip. Its weight was over five pounds and it measured about ten inches by six inches. It was adherent at some point about the brim of the pelvis. The specimen resembled a hepatized lung in color and consistency. The condition was a very rare one.

### ASTRAGALECTOMY AFTER CHOPART'S AMPUTATION

DR. ROYAL WHITMAN presented a girl, aged seventeen years, upon whom at the age of five a Chopart's amputation of the right foot had been performed. The extremity was serviceable until she was fourteen years old, but since then she had suffered persistent discomfort.

The stump presented a typical equinus deformity, the projecting head of the astragalus (Fig. 3) being surmounted by a deep callous ulcer. The ulcer was first excised, and the astragalus was then removed through the usual external incision. The upper part of the os calcis was cut to a plane surface and it was drawn forward and adjusted to the malleoli in a position for normal weight-bearing. The peronei tendons on the outer,



FIG. 3.—Condition of tarsal bones twelve years after a Chopart's operation.



FIG. 4.—Condition of bones shown in Fig. 3 after resection of the astragalus.



## BONE GRAFTING

and the tibialis anticus on the inner side, were attached to its anterior extremity and the wounds were closed.

The changed relation is shown in the X-ray pictures (Figs. 3 and 4), the original Chopart's stump having been changed to that of a modified Pirogoff. There was a slight range of voluntary motion between the os calcis and the tibia which seemed to be advantageous in lessening the direct jar. The functional result was entirely satisfactory.

In a similar but less extreme case now under treatment at the hospital, the tendo achillis was lengthened and such of the anterior tendons as could be freed from the scar tissue were implanted on the plantar surface of the stump, restoring the full range of voluntary dorsal flexion.

Doctor Whitman thought that conservative operations of this type were to be preferred, in childhood at least, to amputations above the ankle, as a weight-bearing heel was preserved. Chopart's amputation had fallen into disrepute because of the failure to provide a secure attachment for the dorsal flexors; thus, consequently, equinus deformity and its consequences were inevitable.

### BONE GRAFTING—STUDY OF A SERIES OF CASES OPERATED ON IN U. S. ARMY HOSPITALS

DR. JOHN B. WALKER presented a paper with the above title, for which see page 1, January, 1921.

DR. CLARENCE A. MCWILLIAMS mentioned the methods of free bone grafting which have been used.

1. Osteoperiosteal grafts according to the method of Delangiere. This is a very successful method and it has not been accorded the notice that it deserves. Delangiere performed 273 operations by this method of which 244 resulted in cures. These grafts consist of periosteum and a thin sliver of bone the thickness of a dime. The grafts could be moulded about a fracture point or made to fill in a bony defect.

2. Intramedullary graft, of necessity without periosteum.

3. Inlay with periosteum:

- (a) Sliding.

- (b) Free, from another site.

4. Lateral, overlying graft always with periosteum.

5. End-to-end graft always with periosteum.

Doctor McWilliams said that if one had the choice between the intramedullary graft and the inlay, one should use the inlay method as being more physiological, because in the inlay we had periosteum and all the layers of bone brought in contact with corresponding layers of the host, while in the intramedullary graft there was no periosteum on the graft, consequently a frequent result of the intramedullary graft was that it was absorbed. Thus, Campbell reported having grafted eight cases, four by the intramedullary method and four by the inlay. All four intramedullary grafts were absorbed while all four inlay grafts remained intact. The speaker said he had in mind an intramedullary graft inserted

by a colleague over a year ago in an ununited fracture of the humerus, which graft, notwithstanding primary union, had now undergone marked absorption and the fracture was still ununited. In making a transplantation of bone, one should choose a method, *i.e.*, the inlay which would permit the retaining of the periosteum on the graft, since the periosteum markedly increased the osteogenic properties of the graft. Delangiere had proved in his 273 osteoperiosteal graftings that a layer of bone with its periosteum produced new bone, that the osteoperiosteal transplant acted not only as a graft, but that it secreted bone. Contrary to the experience of the results of intramedullary grafts, he had never observed absorption of the grafts.

It was difficult to reconcile the various views as to the function of the periosteum. Renfrew White said: "The osteogenetic properties of the periosteum, which it seems to possess, are in fact not its own, but due to a resumption of osteoblastic activity of the cells of minute portions of bone that have adhered to it, having been detached with it."

That there might be an actual outpouring of osteoblasts from the surface of the bone when the periosteum had been ruptured by injury was proved by the reports of cases of traumatic myositis ossificans. It might be that the chief function of the periosteum was circulatory and nutritional, small blood-vessels dipping into the cortical bone from the periosteum—witness the oozing of the blood on a surface of a bone caused by the stripping off of the periosteum. Whatever the specific function of the periosteum was, and this seemed still to be in doubt, all operators agreed now that in making a bone graft the periosteum should be retained on the graft, provided that it was necessary that the graft, to fulfill its function, should not be absorbed, as in the case where a defect was to be filled in by the graft. An intramedullary graft which was implanted without periosteum served merely as a temporary internal splint and was usually absorbed later. Its powers of osteogenesis were feeble, generally speaking. To obtain a graft with the greatest osteogenetic power, one should have periosteum on the graft. Doctor McWilliams concluded from his own experience and from what he had gathered from the literature that the intramedullary splint should be generally discarded because it was but feebly osteogenetic and frequently became absorbed. The inlay method, either sliding or transferred from another site, was much the most certain method in its results when it could be used, since it was most strongly osteogenetic and not liable to be absorbed. When it could be used, owing to the shortness of one of the fragments, the osteoperiosteal graft, as transplanted by Delangiere, should be used. This graft was likewise very strongly osteogenetic and would not be absorbed and could be moulded about an ununited fracture or about a defect to be filled in. The intramedullary graft should be used only when a temporary internal splint was to be provided.

DR. SEWARD ERDMAN asked Doctor Walker whether he had any statistics showing how long a period of time had elapsed from the time of

## BONE GRAFTING

complete healing until operation. Doctor Walker had said that there was an average of 234 days from the time the wound was received until operation, but the fact should be taken into consideration that many of these cases were complicated with osteomyelitis and lay in the hospital with an open wound and osteomyelitis for a long time untreated. It would be interesting to know how long a period elapsed from the time of complete healing until operation was performed, for upon the theory of latent infection in the recently healed wounds, he believed that at least four to six months should intervene between the complete healing of wound and the bone operation.

DOCTOR WALKER, in reply to Doctor Erdman, said the Surgeon General's Office did not have the records available of a large number of cases giving the period of time which had elapsed between the date of complete healing and the date of operation, but from such statistics as were available the result seemed to depend more upon the duration of the original infection than upon the length of time that had elapsed from the date of complete healing until operation. For instance, if a wound had been infected for six months it would be more apt to become infected following bone grafting operation than if it had been infected for only three months. If one took a large number of cases that had been infected for six, eight, or ten months a larger number would be infected following operation than in a similar series in which infection had lasted only three or four months. In the cases he reported non-union had occurred in about 6 per cent. Some writers reported a series of cases in which the percentage of non-union was 12 and 15 per cent. There was a large number of cases classed as non-union, in many of which if one waited six months one would find the union had eventually taken place, so he thought the percentage of non-union was under rather than over 10 per cent.

With reference to the selection of a rib for a graft: he knew of several surgeons who had formerly used ribs and who had come now to the conclusion that the rib should not be used as a graft in those cases of the lower extremity where it would be subjected to weight-bearing. While there was greater cellular activity in a rib graft, it was also true that it would be absorbed more quickly and before new bone could be replaced. More fractures occurred after rib had been used than where the graft had been taken from the tibia. Again the result depends much upon the length of the space which separates the two ends of the fragments. If the ends of the fragments were five centimetres apart a much larger graft should be used than if they were three centimetres apart. Grafts from the rib have been used in repairing defects of the jaw, but later the graft taken from the crest of the ilium seemed to be preferred. For fractures of the radius and ulna, if the ends of the fragments were only two or three centimetres apart one could use smaller grafts. Probably the reason the rib graft gave way in Doctor Hitzrot's case was because it was too small to be used in the lower extremity.

## BOOK REVIEW

LES FRACTURES DU COL DU FEMUR. PAR ANTOINE BASSET, Professeur Agrégé à la Faculté de Médecine de Paris; Chirurgien des Hôpitaux. Annales de la Clinique Chirurgicale du Professeur Pierre Delbet.

Under the above title, Doctor Basset has written an exhaustive monograph on fractures of the neck of the femur. There are 320 pages, followed by reports of 107 cases, and 22 pages of X-rays and other illustrations.

He divides his subject-matter into ten chapters: (1) Classification, (2) Etiology, (3) Architecture of the Neck, (4) Blood Supply of the Neck, (5) Pathological Anatomy, (6) Anatomical Development, (7) Symptoms, (8) Course, Complications and Prognosis, (9) Diagnosis, (10) Methods of Treatment.

Some of the interesting points brought out by Basset's investigations are these: He has injected the blood-vessels of the head and neck of the femur, which spring from two main trunks, the obturator and the femoral. The posterior terminal branch of the obturator artery is the acetabular, which finally penetrates the ligamentum teres and through it reaches the head of the femur, where its arterioles anastomose with the terminal branches of the circumflex arteries supplying the neck. The blood supply of the base of the neck is much more abundant, derived from the anterior and posterior circumflex arteries, branches either of the femoral or profunda femoris. He finds that in the foetus the arterioles penetrate only superficially the cartilaginous tissue and that the zone of union of the head and neck contains very few vessels. There is then no anastomosis between the artery of the round ligament and the circumflex system. In adolescence this condition changes, the anastomosis develops, and the blood supply of the head becomes very rich. In the adult the supply of the head and neck gradually diminishes. Finally in the aged there is a striking diminution in the number and calibre of the vessels supplying the base of the neck and the region of the trochanter.

He maintains that the blood supply of the head persists at least up to sixty-seven years, having examined a specimen at that age. He does not deny the possibility of its failure at a greater age, but strongly doubts it. This point is stressed as it is essential for him to convince his audience that the head always lives, the viability of the head being a necessity in the subsequently described operative treatment. He cites Lambotte as having stated that the head after fracture was exposed to dry arthritis, necrosis and even suppuration (sic); a possibility which seems to be exaggerated.

He concludes (1) that in old people the most common type of fracture is the cervico-trochanteric. (2) In young and middle-aged subjects, while the fractures are usually by decapitation or through the neck, the nutrition of the head is always assured by the artery of the ligamentum teres.

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These conclusions are interesting, as hitherto it has always been adduced in support of the proposition that intracapsular fractures (*i.e.*, through the neck) could not unite, that they occurred most commonly in the aged. Basset, however, directly contradicts this, and later makes the statement that the cervico-trochanteric fracture characteristic of the aged will unite under any form of treatment.

His classification of the type of fractures as (1) by decapitation, (2) transcervical, (3) cervico-trochanteric, (4) trochantero-diaphyseal, seems to me greatly preferable to our vague and misleading "intra- and extra-capsular," and I should recommend its adoption. Basset rejects all statistics bearing on the success of any form of treatment because the exact type of fracture was not specified, a point which looms large, as he later states (page 193) that "fracture by decapitation and transcervical fractures regularly terminate in pseudarthrosis."

He states that the aims of treatment of fracture of the neck of the femur are the following: (1) To obtain consolidation in the best possible attitude of the fractures which do not unite by bony callus—that is to say, of true cervical fractures, which end in a pseudarthrosis with pain, progressive shortening, and finally almost complete infirmity. (2) To obtain consolidation in correct attitude, of fractures which unite by bony callus, that is to say, the cervico-trochanteric variety. (3) To get the patients up as soon as possible. (a) In order to avoid pulmonary, urinary and cachectic complications in old patients (cervico-trochanteric fractures). (b) In order to combat muscular atrophy and to correct it if it exists (in old fractures) and to avoid it if it does not exist (in recent fractures).

Upon the state of the musculature of the limb will depend, in large part, the quality of the functional result.

He then describes at length the various methods of treatment, giving a full, clear and accurate account of the abduction method, but being sceptical of its success because he cannot conceive of a plaster spica extending from the ribs to the toes being comfortable; nor can he conceive how a patient so encased could be turned upon the face or moved about.

The last chapter appears to be the *raison d'être* of the book and is a description of Doctor Delbet's operative method. It is apparently his custom to operate on all cases, because (1) he believes that fractures by decapitation and transcervical fractures never unite under any treatment other than operative (page 262). (2) He, as he believes that cervico-trochanteric fractures normally unite under any form of treatment, concedes that all methods are capable of giving more or less favorable results. He objects to the abduction method because of the difficulty of the application of the plaster, its burdensomeness to the patient, and the length of the treatment. (3) He objects to arthrotomy as exposing the patient to grave risk, and still further compromising an already compromised blood supply.

The patient is placed upon the table with traction on both legs to reduce

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the shortening, and the great toes tied together. The surgeon makes an incision over the base of the greater trochanter, and having determined the position of the head, and the angle and inclination of the neck by the use of a special instrument Doctor Delbet has devised, or by radiography, he introduces a wooden screw through the neck into the head, and thus presses the fragments firmly together. The screws are made in lengths of 7, 8, 9 cm., according to the individual case. The diameter is always 6 mm. The thread is made unusually deep. He believes that the screw "plays a transitory but very important rôle. It causes osteosynthesis, maintains the reduction of displacement and the accurate and close-pressed coaptation of the fragments" (page 270). The screw soon becomes loose, but it has not been necessary to remove it except in a few exceptional cases where it had slipped, being badly placed, or at the request of the patient.

In the cases of old fractures with pseudarthrosis he substitutes for the screw a bone graft consisting of a section of the shaft of the fibula from which all the periosteum has been carefully removed "in order to open the Haversian canals giving on the surface of the graft, and to facilitate the establishment of vascular connections between it and the bony tissue in the midst of which it is introduced." Doctor Delbet believed at first that this graft would simply serve to bear the weight of the patient and would not generate bone (page 280). Doctor Basset now believes that there has been definite formation of new bone in five cases of pseudarthrosis, in which the radiograph has shown reconstruction of the neck. In the two classes of cases he believes "that in the first period the screw and the graft have the same advantage. The first in recent fractures and the second in pseudarthroses permit one to make the patients get up and walk some days after the operation." He finds, that, though the graft has been taken from the fibula by an "imperfect subperiosteal resection" and the periosteum having retained throughout its vascular connections, there has been no regeneration of new bone in the shaft of the fibula.

As soon as possible after the operation and not later than the fourth or fifth day one begins muscular exercises. One makes the patients contract the muscles of the thigh and stiffen the leg without moving it. These exercises are very important, for almost all these patients, and above all those operated for pseudoarthrosis, have muscular atrophy, which hampers them extremely when they begin to walk.

The period at which the patients get out of bed varies according to two conditions: (a) According to whether it is a question of recent fracture treated by screwing, or pseudarthrosis treated by an osseous graft, (b) according to whether or not one has applied the "*appareil de marche à extension continue*" (walking splint with continuous traction) (I shall refer to it for convenience as Delbet's splint).

"After screwing, patients not provided with Delbet's splint get up from the twelfth to the thirtieth day; those who have it, from the third to the

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thirteenth day. After graft, those without the apparatus get up from the twentieth to the sixtieth day, and those with it from the tenth to the fortieth day.

"From the moment that the patients get up, whether it be a question of screw or graft, and whether or not one has applied the Delbet splint, one makes the patients first walk with crutches, obliging them (and this is important) to concentrate on making correct movements of walking. As confidence returns they pass from crutches to canes. In general, progress is slow, especially when the pseudarthrosis is of long standing. But usually they improve with time, above all when energetic and persistent patients take pains to perfect their gait."

After the operation, and in spite of it, it happens in certain cases that walking remains during a certain time, sometimes very long, difficult and defective. There are several reasons for this—"timidity of the patient, muscular atrophy, a certain limitation of motion in the hip, a little shortening and slight external rotation of the limb."

In summarizing Doctor Delbet's operative results in the table below I have classed as "perfect" those cases resulting in "restitutio ad integrum," those able to walk well and go about their ordinary affairs with little if any pain I have called good. I have counted out all results under six months following operation, as I am convinced that under that time, at least, one can never be certain that bony union has taken place.

He also cites five cases of cervico-trochanteric fracture treated by the Delbet splint alone, of which the results seem quite as good as those in which the operation was performed. The number of cases in which a second operation was necessary or in which there was imperfect position of the screw or graft confirms the impression that the method is distinctly one to be employed only by the expert.

*Treatment by Decapitation.*—Insertion of screw—5 cases. Results: Perfect, 1; good, 2; unknown, 1; too soon to classify, 1.

*Transcervical Fractures.*—Insertion of screw—26 cases. Results: Perfect, 3; good, 7; failure, 2; too soon to classify, 8; unknown, 2; deaths, 4.

*Cervico-trochanter Fractures.*—Insertion of screw, 14. Results: Perfect, 1; good, 3; too soon to classify, 5; unknown, 1; deaths, 4.\*

*Pseudarthrosis-Fibular Graft.*—Twenty-five cases (11 fractures by decapitation, 12 transcervical). Results: Good, 12; failure, 15; too soon to classify, 4; deaths, 2.

We have, then, out of a total of 107 cases observed 70 selected as suitable for operation. Of these 70, 25 were cases of pseudarthrosis, leaving 45 cases of fresh fracture operated upon by Doctor Delbet's method. Of these 45, 17 results were perfect or good. There were 7 deaths and 2 failures, the others either were too early to report as final results, were poor, or were lost track of.

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\* One as result of accident six months later.

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For purposes of record, therefore, all that we are entitled to say of the operative treatment is that by its use good results have been obtained in 37 per cent. of cases, and that it has been attended by a mortality of 15 per cent. Only 54 per cent. of cases were considered suitable for operation.

I have quoted Doctor Basset at great length because I wished to be accurate and to be certain that I had stated his case fairly. The preliminary chapters are so excellent and the scale of the work so monumental, that there is great danger of the superficial reader, and particularly of the general surgeon, thinking that one who writes so carefully must reason equally well, and adopting his conclusion that all fractures of the neck of the femur should be treated by operation.

Taking up his case categorically, therefore, I begin with the statement that fractures by decapitation and transcervical fractures never unite under ordinary treatment (page 232). Sir Astley Cooper cites a case which united under no treatment whatever, Willis Campbell gives a series in which the cases were carefully divided into intra- and extra-capsular fractures in which he obtained union in twenty-four out of twenty-nine of the first variety. (*ANNALS OF SURGERY*, November, 1919). Let us concede, however, that all statistics are false, and that Doctor Basset is correct in his statement. What then is the magic power inherent in the wooden screw? "It maintains the reduction of displacement and assures close-pressed coaptation of the fragments" (page 270). Proper reduction of a recent fracture and maintenance of full abduction will give as close-pressed coaptation as can any screw. The curiously minded may verify this statement for themselves either by open operation or investigations on the cadaver. This is not true of old cases in which the neck has been absorbed, and it is unfortunate that Doctor Basset did not separate his cases into fresh and old fractures. Also, he says that the screw eventually becomes loose. He particularly says that it is not inserted for the purpose of bearing weight; but there is some confusion on this point, as on page 268 he objects to the use of a thin nail as being "too feeble to support the weight of the body when one gets the patient up;" that at the end of a certain time a rarefying osteitis is produced about it, and that it plays freely in the enlarged canal. From my experience I should say that six weeks would certainly have seen the establishment of this condition. The diameter of the neck is about 16 mm. The diameter of the screw is 6 mm. Having thus diminished the potential strength of the bone at least one-third, does it not seem remarkable that the patient should be encouraged to bear weight upon it as soon as the twelfth to the thirteenth day? This seems the more extraordinary when we remember that this is the only fracture except oblique fractures where the body weight falls directly across the line of fracture. We are all familiar with the solicitude displayed to keep patients with oblique fracture of the femur or tibia from bearing weight until such time as consolidation shall have become secure.

How are we to explain the fact, then, that in the face of these seemingly

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grave mechanical and pathological difficulties a wooden screw caused firm bony union? Probably, I think, by the fact that the patients themselves used their crutches longer than their observers supposed, or wished to suppose, and that Doctor Delbet's splint, which I regret Doctor Basset does not describe in detail, prevented them from bearing any weight upon the injured limb. I am strengthened in this opinion by the fact that in three cases of pseudarthrosis (xlv, lvii, lxviii) the graft taken from the fibula broke. If the whole diameter of the fibula could not sustain the body weight, I find it almost impossible to believe that new-formed callus with no external callus, and only a loose-playing 6-mm. wooden screw to reinforce it internally should be capable of doing so at such an early period as the twelfth to the thirtieth day. Probably Doctor Delbet's splint takes the body weight upon its upper ring, as does the ordinary traction hip splint which we are accustomed to use. I am practically certain of this point because Doctor Basset refers to it as "*l'appareil de marche a extension continue*" (walking apparatus with continuous traction) and obviously no traction could be possible were weight borne upon the limb. The object of the operation in fresh cases, therefore, becomes simply efficient fixation of the fracture, which may be equally obtained by non-operative means. The recommendation of the operation for all cases is a vicious practice, however, because in many cases deformity is not reduced, as Doctor Basset himself states. Without arthrotomy, having no control over the head fragment, abduction to the normal limit is the only position in which form is restored, and one cannot reiterate too often that restoration of form is the essential preliminary to the expectation, even, of restoration of normal function.

In fractures of the cervico-trochanteric variety, which Doctor Basset states will unite under any form of treatment, the performance of the operation is still more inexplicable. Its only purpose could be the correction of deformity and this it does not do.

In cases of pseudarthrosis the question is quite different. Then the neck has usually atrophied and has disappeared, and any operation which will get union of the parts that remain, and provide a stable, painless, weight-bearing extremity is to be commended. Certainly the pegging operation, if one is possessed of the necessary skill, is a less formidable and less damaging procedure than arthrotomy, but in the cases of ununited fracture which I have seen the fractured surface of the head was so covered with dense fibrous tissue as to make the possibility of union without freshening the surfaces seem most unlikely. This question, of course, can only be decided by personal experience.

The underlying reason for disquisitions upon the operative treatment of fracture of the neck of the femur is that surgeons in general are unable or unwilling to master the details of and to learn to apply the abduction method. In their anxiety to evade that necessity they seek refuge in various operative

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methods under the excuse of age, or character of the patient, with the familiar refrain that such patients will not stand confinement to bed.

Doctor Basset evidently has studied this method, but that he cannot be familiar with its application is indicated by the fact that he cannot understand how a plaster spica extending from the axillæ to the toes can be spoken of as comfortable, nor how a patient wearing such apparatus can be turned over in bed. Certainly I do not pretend that to be so encased is agreeable, as life in a spica must naturally be in the nature of a strange experience to any but a crustacean. But, I may truthfully aver that such a plaster properly applied may be very far from uncomfortable. The question of moving the patients once the plaster has hardened is simply a matter of strength or skill, and they may be got out of bed if necessary at the end of forty-eight hours. Sir Robert Jones, who habitually uses an abduction frame in his treatment of this fracture, makes it his practice to apply plaster when he particularly desires to get his patients early up and about.

The principles of the treatment of fracture of the neck of the femur have been continually obscured by extraneous matter such as the age of the patient, the desirability of early locomotion, and the fact (?) that intracapsular fractures of the neck did not unite. All those questions may affect the treatment of a given case, but they have nothing whatever to do with the principles governing the treatment of all fractures. The primary essential is the reduction of deformity, and the maintenance of such reduction until consolidation shall have taken place. If deformity is allowed to persist any expectation of perfect function is absurd. Without arthrotomy the normal relationship of the fragments in a fracture of the neck of the femur can only be restored by reducing the shortening and holding the limb in a position of slight inward rotation and at the limit of normal abduction. This is the fundamental principle of treatment, and once it is understood one may expatiate as one pleases upon the discomforts of plaster-of-Paris, the unpleasantness of treating old people, the unwillingness of intracapsular fractures to unite, and the necessity for getting the patients early out of bed.

Whoever undertakes to prescribe one remedy for all cases of a certain injury must have sound reasons for so doing, and has no reason to complain if others of less positivistic tendencies take issue with him.

To restate Doctor Basset's case as briefly as is consistent with fairness, he is dissatisfied with conventional methods of treatment of this crippling injury, and with their wretched results. He is unwilling to accept the abduction method because it is difficult of application, and because if plaster-of-Paris be employed the plaster is heavy, cumbersome and painful to the patient to wear, which he should do for several months. He, therefore, advises for fresh fractures the insertion of a wooden screw, and for old ones with non-union and pseudarthrosis the insertion of a bone graft, consisting of a section of the shaft of the fibula.

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Both methods assure close-pressed coaptation of the fragments and enable the patient to get up and about with the assistance of a splint at periods varying from the third to the sixteenth day, and to begin early to bear weight upon the limb.

In the discussion of such a radical proposition as a standard operative treatment for all forms of an injury one must separate sharply theory and practice. It is a scientific truth that in order to restore the normal form of the bone in a fracture of the neck of the femur, one must either do so by open operation and direct manipulation of the fragments, or, having overcome shortening by traction, to abduct the limb to the normal limit of abduction, to rotate it slightly inward and in such a position to maintain it until bony union shall have become secure. In other words, if one expects a perfect functional recovery, one must apply the same elementary principle to this fracture as to any other reduction of deformity.

If for any reason the application of methods for the reduction of deformity are impossible or inadvisable, one then may have recourse to something else, but with the clear understanding that in so doing one is compromising and sacrificing ultimate function for other more immediate considerations.

The primary weakness of Doctor Delbet's method is, that deformity is not reduced. I consider this point so important that I take pains to give Doctor Basset's own words (pp. 315 to 316): "Why, in the case of which we have just spoken, does there persist after the operation a certain degree of shortening, or a little separation (decalage—literally unwedging of the fragments)?"

It is because in certain fractures, and in particular in certain cases of long standing pseudarthrosis with accentuated deformity, whatever be the continuous traction that one makes upon the foot during the operation, and in spite of the general anæsthesia, one does not succeed in entirely reducing the displacement of the fragments. The introduction of a screw with energetic pressure or the insertion of an osseous graft fixes the fragments in the attitude of slightly imperfect reduction. In my opinion this statement by itself is enough to condemn the method as a standard treatment.

It is evident that Doctor Delbet's interest was aroused by the unfortunate lot of the patient with an ununited fracture, and eventually finding a method of treatment which gave him favorable results in such—the worst cases—he gradually expanded it to the treatment of all such injuries. He probably argued that under conventional treatment there was always a chance of non-union, and that if he could shorten convalescence and insure a firm, weight-bearing extremity, he was justified in the sacrifice of perfect function.

This process of development is in direct contrast to that of the abduction method, which was first tried upon children, later on young

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adults, and very gradually expanded to the treatment of all types of cases. Though it is slowly coming, in this country and elsewhere, to be recognized as the standard treatment, I know of few who would be bold enough to say that it should be applied to every case.

Apart from the author's chapter on operative treatment, I have nothing but praise for Doctor Basset's book. It gives evidence of long and painstaking work in the collection of material, its style is excellent, and the subject is fully covered in all departments. It is a valuable contribution to the literature in a field which has not often attracted investigators of Doctor Basset's ability. I regret that we have in this country so little work that can be compared to it.

ARMITAGE WHITMAN.

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